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## OPERABILITY OF BRAIN TUMORS \*

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THE operability of brain tumors is, I believe, worthy of discussion since many physicians still hold the opinion that all patients with brain tumor have a hopeless disease. Many tumors are inoperable because of their malignant structure, or are inoperable on account of their inaccessibility, but a fair-sized group can be removed completely. A larger group can be removed subtotally or by the intracapsular method. The increased intracranial pressure produced by the inoperable tumor is frequently relieved by suitable decompressions. The interval of relief often is increased in length by the aid of radiotherapy. Diagnostic and pathological aspects will be referred to but briefly, since I wish to emphasize the fact that surgical treatment of brain tumors is more than a hopeless and worthless procedure.

Surgery of the brain has made rapid progress in recent years following the introduction of antisepsis, asepsis, and improvement in cerebral localization and surgical technic. Neurologists, ophthalmologists, pathologists and radiologists have contributed much to knowledge about the behavior of tumors of the brain. Until the last two or three decades, most general surgeons were more concerned with the technic of craniotomy than they were with the problems of treatment for tumor. This is responsible for the development of a new surgical specialty known as "neurosurgery." The neurosurgeon is qualified to evaluate clinical, neurological and laboratory findings and is trained to execute the accepted modern surgical procedures in the treatment of patients who have tumors of the brain.

HISTORICAL SKETCH.—Cranial surgery dates back to the ancient Egyptians, Romans, and Peruvians, who trepanned skulls to give egress to the evil spirits within, but who also must have treated injuries of the skull if explanation is to be made of the extensive defects present in the skulls preserved in museums. Traumatic cranial surgery, undoubtedly, was practiced during the various epochs before modern antiseptic and aseptic surgery were introduced.<sup>18, 20</sup> Records show that this was true during the Napoleonic wars. The depth of the surgical procedures was limited by the dura, as those who penetrated below the dura met with failures resulting from suppuration.

Richmond Godlee,<sup>5</sup> of London, is accredited with being the first successfully to remove a tumor of the brain. The tumor had been localized by Ben-

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nett, who employed the newer neurological methods. Godlee was able to accomplish the removal by employing Lister's antiseptic technic. The date of this operation was November 25, 1884, and the results of the procedure were reported in 1885. Ballance, in his monograph, "A Glimpse into the History of Surgery of the Brain,"<sup>3</sup> stated that Heyman, in 1831, had removed a tumor of the parietal bone from a patient, eight years of age, who presented Jacksonian convulsions. Other similar references are found in literature, but the reports differ from Godlee's in that localized cranial signs, such as presentation of the tumor through the bone, led to the localization rather than the neurological symptoms which Bennett observed in localization of the growth. MacEwen, as early as 1876, had diagnosed an abscess of the frontal lobe because of the contralateral hemiplegia, and had proposed operation, which had been refused by the parents of the patient. Subsequently, the patient died and MacEwen carried out the steps of his proposed operation at necropsy, and found the abscess. He too had operated on several tumors of the brain, using lesions of the skull as localizing signs, before Godlee had operated in his famous case. However, MacEwen's report of abscess entitles him to be called the father<sup>45</sup> of modern neurological surgery. In the discussion of Godlee's paper, Ferrier<sup>27</sup> reported a case in which a tumor of the brain had been localized neurologically; Lister had trepanned but had failed to expose the tumor, but he did so eight days later at necropsy, when he found the tumor in the region explored. At the reading of Godlee's paper, Horsley also was present, and because of his interest in neurology and in the restriction of a surgical field to that of the central nervous system, it made him the outstanding leader in the pioneer development of neurosurgery.

Weir, of Philadelphia, is accredited with being the first surgeon in the United States successfully to have removed a tumor of the brain. This operation was performed November 17, 1887, and was reported in 1888.<sup>41</sup> In 1891,<sup>40</sup> Keen reported five cases in which cerebral operations were performed. In the first, that of a patient with traumatic epilepsy, he implanted decalcified bone from the tibia of a bullock, with reported recovery from epilepsy for eight months and with partial preservation of the integrity of the implanted bone. His second case was similar to the first except that the transplant had disintegrated. The third case was one in which he trepanned the skull for delusional insanity resulting from trauma; the immediate temporary relief was followed by recurrence of symptoms. In the fourth case, in which exploration for brain tumor was performed, the patient succumbed to operation. The fifth case was one in which he trepanned for defective mental development and in which the patient died twenty minutes after operation from hæmorrhage. In the same year, C. H. Mayo<sup>49, 50</sup> reported two cases, the first of successful drainage of a brain abscess and the second of ligation of a common carotid artery for arteriovenous fistula in the cavernous sinus, with a successful result. Knapp,<sup>42</sup> of Boston, in 1891 collected from the literature and reported forty-six cases in which operation had been performed in

## OPERABILITY OF BRAIN TUMORS

the preceding six years and stated that thirty patients had survived the operation, fifteen had died, and one had not been reported. Keen, in 1895, commented on the fact that in spite of the rapid progress and brilliant achievement of modern antiseptic surgery, cerebral surgery had made but little advance until 1886, when Horsley and MacEwen had introduced radical changes in surgical technic.

The prophesies of Keen, Horsley, and von Bergmann have been fulfilled, since the surgical mortality following craniotomy has been greatly reduced and the results have become infinitely better as the knowledge of localization has advanced and the surgical technic improved. Harvey Cushing has been the chief exponent of these present changes, and he has urged that the neurosurgeon be a neurologist as well as a surgeon and that he be specially trained to carry out delicate operations. In 1908, he<sup>9</sup> presented a comprehensive review, "Surgery of the Head," in which he called attention to the changes made in surgical technic. While Horsley still employed chloroform in conjunction with morphine as an anæsthetic he advocated etherization and the use of local anæsthesia in selected cases. He referred to the use of the Heidenhain stitch for controlling bleeding of the scalp, but chose to use Esmarch's bandage. During this period the Toison chain saw (1891) and the Obalinski-Gigli flexible-wire saw replaced chisels and gouges in elevating an osteoplastic flap. He accepted the Gigli saw as the best and employed Doyen's burrs in making the trephine openings. Cryer's spiral osteotome was still employed by some surgeons, DeMartel and Frazier being its chief exponents. Dahlgren and DeVilbiss devised instruments for cutting the skull following a trephine opening, and they employed this procedure for elevating an osteoplastic flap. Cushing recommended the Dahlgren forcep for narrowing the edges of the bone flap at the base. He employed Horsley's bone wax for controlling bleeding, and described electrodes for stimulating the cortex to determine localization. He introduced the present method of closure of the scalp with interrupted silk sutures in the various layers. He has presented numerous monographs on the physiology of the brain and on the pathology of tumors, and has introduced many innovations in the surgical approach and removal of tumors. One of the most valuable innovations in the field of neurosurgery has been the introduction and use of the electrosurgical unit. This unit is a modification of Pozzi's fulguration apparatus, by Bovie, who combined a coagulation or diathermy unit with a desiccating, cutting unit in the same machine, so that it was possible to switch from one current to the other over the same electrode, thus making it possible to remove tumors piecemeal and instantly to have in readiness a coagulation current for control of bleeding. This appliance has made it possible to increase the scope of neurosurgery to include a large group of benign tumors situated in inaccessible places. The electrosurgical unit has also expedited resection of infiltrating tumors, and has facilitated control of hæmorrhage during lobectomy. Frazier, Elsberg, Taylor, and many others in this country and abroad have likewise contributed to the refinement of surgical technic.<sup>24</sup> Dandy, with the intro-

duction of pneumoventriculography and pneumo-encephalography, has supplied a mechanical means for further perfecting the localization of new growths that is of inestimable value.

**PATHOLOGY.**—In order to evaluate the operability of brain tumors, I reviewed a series of consecutive cases of brain tumor in which patients were operated on at The Mayo Clinic in the last eighteen months, from April, 1931, to September, 1933. This series was found to include 220 cases. In 167 cases, the situation of the tumor was verified, but it was unverified in fifty-three cases even though the clinical and surgical findings suggested the existence of subcortical tumors. The tumor was removed completely in nineteen (8.6 per cent.) and subtotally in 109 (49.5 per cent.) of the cases. The classification, subtotal removal, included all cases in which there remained any possibility of tumor-cells having been left. The subtotal group included thirty-two pituitary tumors and nineteen neurinomas of the acoustic nerve. The anatomical situation of cerebral tumors is given in Table I.

TABLE I  
*Situation of Tumors*

Supratentorial	
Frontal lobe.....	37
Temporal lobe.....	30
Parietal lobe.....	26
Occipital lobe.....	6
Lobe of anterior fossa.....	12
Suprasellar region.....	6
Pituitary gland.....	26
Corpus callosum.....	2
Mid-brain.....	3
Third ventricle.....	5
Multiple.....	1
Total.....	154
Infratentorial	
Cerebellum.....	28
Cerebellopontine angle.....	23
Fourth ventricle.....	15
Total.....	66

Seventy per cent. of the tumors were situated above and 30 per cent. below the tentorium. Forty-five per cent. were encapsulated and 31 per cent. proved to be infiltrating tumors; 24 per cent. were unverified. Of tumors in the encapsulated group, 15 per cent. were meningiomas, 8.6 per cent. neurinomas, and 14 per cent. pituitary tumors. The pathological classification is given in Table II.

From these data it is apparent that surgery of brain tumors is not such a hopeless procedure as it once was thought to be. Although total and subtotal removal of tumors is limited to 58.1 per cent. of cases, the temporary relief of intracranial pressure by decompression, with supplementary relief



# OPERABILITY OF BRAIN TUMORS

TABLE II  
*Pathological Classification*

Encapsulated Tumors		Infiltrating Tumors	
Meningiomas.....	34	Spongioblastomas multiforme.....	17
Pituitary tumors, including 6 adamantinomas.....	32	Astrocytomas, fibrous.....	14
Neuromas.....	19	Astrocytomas, protoplasmic.....	10
Ependymomas.....	6	Medulloblastomas.....	9
Hæmangio-endotheliomas.....	3	Oligodendrogliomas.....	6
Chordomas.....	2	Oligodendroblastomas.....	5
Ganglioneuroma.....	1	Astroblastomas.....	2
Lipoma.....	1	Polar spongioblastomas.....	2
Cholesteatoma.....	1	Metastatic lesions.....	2
		Sarcoma of meninges.....	1
	99		68

from radiotherapy, has diminished the symptoms and prolonged the lives of additional patients with inoperable growths.

**PRESENT TECHNIC OF CRANIOTOMY.**—Although neurosurgeons adhere to the principles of meticulous care in handling tissue and in control of hæmorrhage, as introduced by Cushing, Frazier, Elsberg, and by others, I believe it would not be amiss to discuss some of the present technical problems of craniotomy before entering into specific discussions on removal of various types of tumor.

The choice of anæsthetic agent has varied from time to time among various surgeons, and I have been guilty of trying the various anæsthetic fads, but I have always returned to the use of ether anæsthesia, since I have learned that drop ether inhalation can be employed with safety and without rise of blood-pressure if administered on an open mask held over a Magill intratracheal tube which has been introduced through the nose or mouth into the trachea. The tube insures a free, unobstructive airway which decreases the force and frequency of respiratory excursions usually produced by ether anæsthesia. The intratracheal tube is inserted after the patient has been anæsthetized with ethylene or ether but prior to preparation of the surgical field. It allows the anæsthetist to remove tracheal mucus during the operation by inserting through the tube into the trachea a catheter connected to a suction apparatus. It also serves as an emergency measure for administration of oxygen and permits the anæsthetist to oxygenize the patient thoroughly at the completion of the operation.

**Preparation of the Surgical Field.**—Again, various types of antiseptic preparations have been employed, depending on surgical acceptance of the chemical preparations presented by pharmaceutical houses. The surgical field, although not always the entire head, is shaved, then cleansed with soap and water and with solutions of ether and alcohol preliminary to the application of two coats of an alcoholic solution of merthiolate 1:1000. I further protect the wound by suturing a sheet of sterilized rubber dam about the proposed surgical field. The rubber dam is of sufficient size to extend from the head over the instrument table. In addition, the usual sterile towels and sheets are applied and held in place with interrupted sutures of silk. (Figs. 1, 2, 3 and 4.)

ALFRED W. ADSON

Supratentorial tumors are usually explored through osteoplastic flap craniotomies, whereas infratentorial tumors are explored through suboccipital decompression types of craniotomy. Tumors situated high in the cerebellopontine angle, or tumors that arise from the tentorium or are situated in the region of the brain stem, often require for exposure a combination of osteoplastic flap and suboccipital craniotomy.<sup>51</sup> Occasionally, a large decompression through a musculocutaneous flap affords sufficient exposure to remove a tumor.

Scalp and bone flaps are arranged to preserve the blood supply and to give the desired intracranial exposure without producing disfiguring scars. Bleeding from the cut



FIG. 1.—Preparation of surgical field, outline on scalp indicates proposed osteoplastic flap.

edges of the scalp is controlled by one of two procedures. One method is to apply pointed forceps to the galea and turn it over the edge to serve as a compressor of the scalp. The other is to apply hæmostatic scalp clips to the full thickness of the scalp. The clip originally was devised by Willis Andrews, but it was modified by me in order to control all bleeding, and so that it would remain in place during the operation without injuring the edges of the scalp. This I have accomplished by designing a clip from a rectangular piece of German silver. The centre is removed, leaving a rectangular border which is turned on itself to form a U-shaped clip. Teeth are placed on the four corners which serve to fix the clip on the scalp when applied with a holder. I have found that it meets all requirements without the added annoyance of having dozens of hæmostats hanging on the scalp. After the scalp is incised, the periosteal flap is made larger than the proposed bone flap in order that it can be turned back over the cut edges of the bone flap, burr

## OPERABILITY OF BRAIN TUMORS

openings and sawed edges. The saw is held in such a position as to produce a bevel on the cut edges of the bone flap. This later supports the flap and prevents it from falling

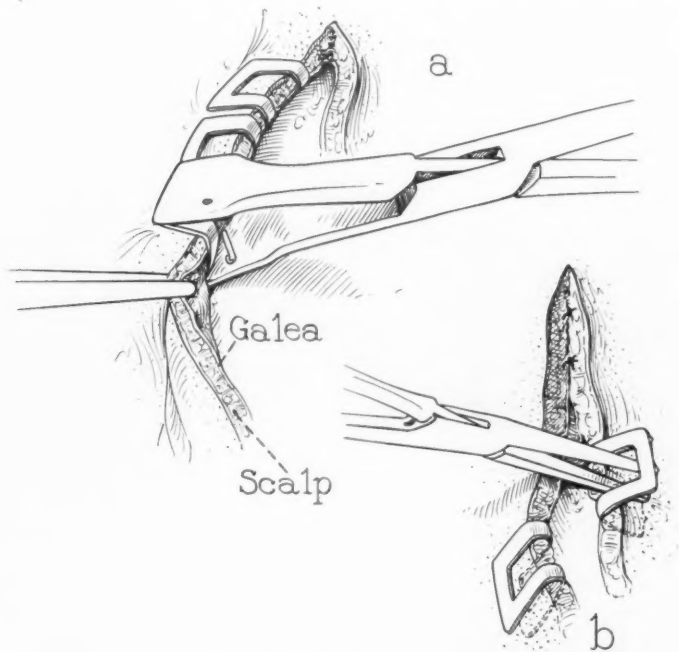


FIG. 2.—(a) Application of clips to scalp for hæmostatic purposes, and (b) removal of clip with pointed forceps preliminary to suture of galea with interrupted silk sutures.

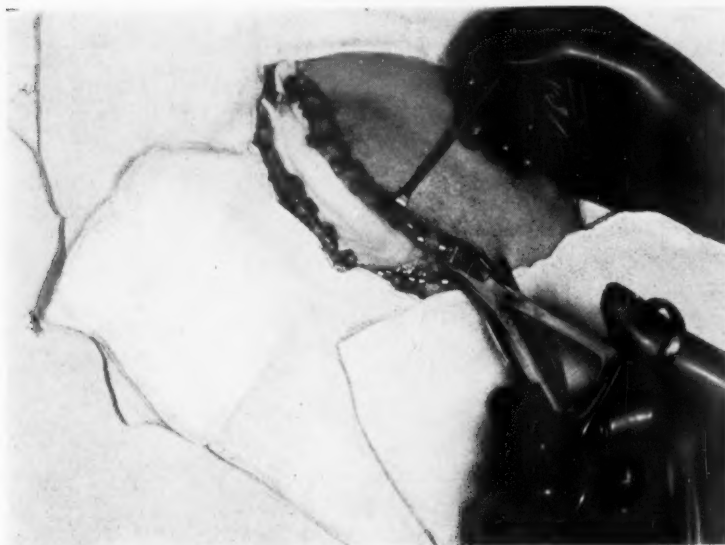


FIG. 3.—Application of hæmostatic scalp clips.

onto the brain. The base of the flap in the region of the temporal muscle can be sawed, but usually it is broken after the edges have been narrowed by making a groove on each side with DeVilbiss bone biters. Bleeding from the bone flap can be greatly reduced by

separating the periosteum from the bone opposite the groove made by the meningeal vessels. The remaining emissary and diploic channels<sup>38</sup> are sealed with Horsley's bone wax or by the electrocoagulating current. Dural vessels are controlled by silk ligatures, silver clips, and by the coagulation current if the bleeding vessel is small and is not situated over the motor area or along the longitudinal sinus, since there is danger of coagulating the underlying cortex or of encouraging thrombosis from the veins to extend into the longitudinal sinus.

The technic of closure of the scalp has changed but little since it was introduced by

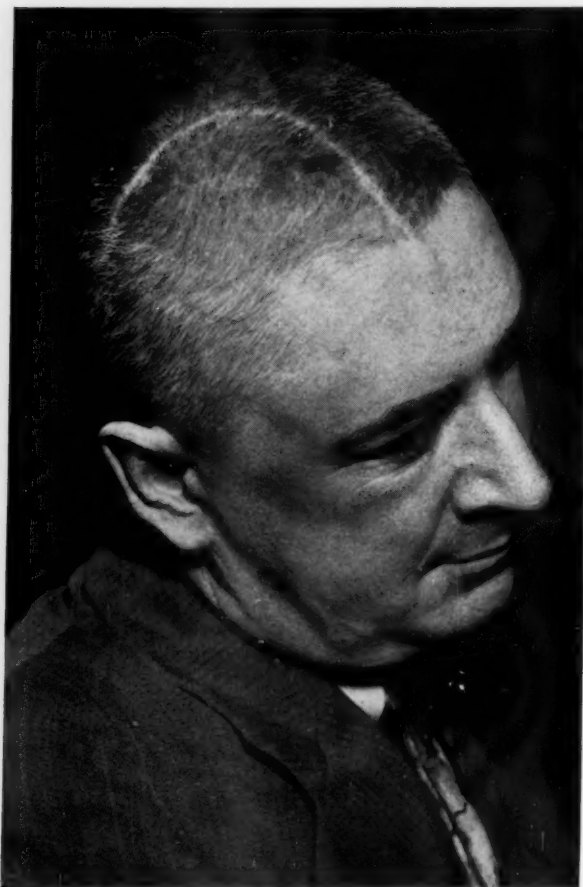


FIG. 4.—Appearance of wound two weeks after intracapsular enucleation of a pituitary tumor; hæmostatic scalp clips were used.

Cushing. The best wounds are obtained by careful approximation of the bone flap, periosteum, muscles, fascia, galea, and skin by interrupted silk sutures. Tying of the bone flap with three interrupted sutures of silk, which have been threaded through gimlet openings placed opposite each other in the skull and flap, prevents elevation and overriding of flap and subsequent disfiguring hernias in cases of irremovable tumor. Burr openings are filled with bone dust which has been made into pledgets by wrapping animal membrane about sufficient ground bone, obtained at the time of opening, to fill the hole. Drains are rarely used but, if it is necessary, a waiting suture is placed in the scalp opposite the drains at the time of operation; this is tied promptly following removal of the drains. Cushing and his pupils have preferred to cover the margins of the wound with silver foil; others employ gauze soaked in alcohol. Massive crinoline bandages which cover the sterile dressings have been universally employed by Cushing and his pupils, but this too has been

found to be unnecessary by other surgeons who use the roller bandage over a head gauze to protect the sterile dressing. The subdermal stitches make it possible to remove the superficial stitches on the third or fourth post-operative day, thus avoiding subsequent stitch marks.

Most surgeons prefer to complete the operation in one stage and, if necessary, resort to blood transfusions during the operation. Acacia may be substituted for blood in an emergency. Occasionally, it is necessary to give hypertonic solutions intravenously, to reduce the intracranial pressure sufficiently to permit opening of the dura without causing prolapse of brain.

## OPERABILITY OF BRAIN TUMORS

REMOVAL OF TUMORS.—Surgically<sup>1, 8, 14, 55</sup> tumors of the brain are placed in two large groups, the one including encapsulated and accessible infiltrating tumors, and the other, diffuse infiltrating inaccessible tumors. It is apparent that the encapsulated accessible tumor best lends itself to surgical removal; however, the infiltrating tumor, when situated in a silent area, also can be removed by including the brain about the tumor. More often than not, in the group of cases of nonencapsulated tumor, the surgeon is compelled to perform subtotal resection, removing necrotic cystic material with mural nodules and masses from within the tumor in order to avoid increasing the existing paralysis. Radical resections of diffuse infiltrating tumors are avoided if removal of the tumors may result in hemiplegia. I prefer to secure the shorter period of relief, with preservation of more normal function, than the extended, indefinite period with the possibility of spastic hemiplegia. Decompressions should never be substituted for removal of tumors when it is at all possible to perform radical operation, but they do serve as auxiliary measures in subtotal resection of tumors and also serve as measures of temporary relief in the treatment of many patients with inoperable tumors.

*Meningioma.*<sup>26, 31, 33</sup>—These tumors arrange themselves into three groups: (1) those that develop along the large sinuses, for example, along the longitudinal and lateral sinuses; (2) those that develop under the brain in the fossæ of the skull, and (3) those that develop over the surface of the brain. They grow slowly, vary in pathological structure, and develop from arachnoid cell clusters and villi. They are rounded, encapsulated, lobulated masses, usually occurring as a single growth, and vary in size from that of a pea to that of a large orange. The exceptions are, however, that they occasionally are flat and thin, and they may be multiple and undergo malignant changes. They invariably are adherent to the dura even though they originate within the arachnoid. Complete removal is not made unless all of the involved dura is included with the tumor; the same is true of all involved bone, unless one wishes to follow Naffziger's suggestion of trimming, boiling, and replacing the bone flap.

*Parasagittal Meningioma.*<sup>25</sup>—These tumors usually are confined to one side of the falx, but they extend to the other side often enough to require exploration if the longitudinal sinus is found thrombosed or filled with tumor-cells. The overlying skull is usually hypertrophied, giving evidence of parasagittal osteoma. The osteomas vary in size, depending on the duration of the tumor. The hypertrophied bone is always invaded with tumor-cells; occasionally, this is so extensive that parts of the osteoma have been replaced with tumor tissue. Now and then the dura is free from bony attachments, but it is usually adherent in the centre of the tumor to a small spicule or prominence that grows from the inner table of the skull into the tumor.

The scalp and bone flaps are planned thoroughly to expose the tumor but, at the same time, to be so elevated that hæmorrhages are controlled and injuries to the lateral communicating veins and to the longitudinal sinus between the entrance of the communicating veins and torcula avoided, for if



these are injured or thrombosed, unilateral and bilateral paralysis develops. The paralysis will be complete in the lower extremities although incomplete in the upper extremities. Partial recovery finally takes place, but the complication is a serious sequela. If one were sure the meningioma was unilateral, it could be readily exposed by an osteoplastic flap which had its base in the temporal region and the upper margin placed parallel along the lateral

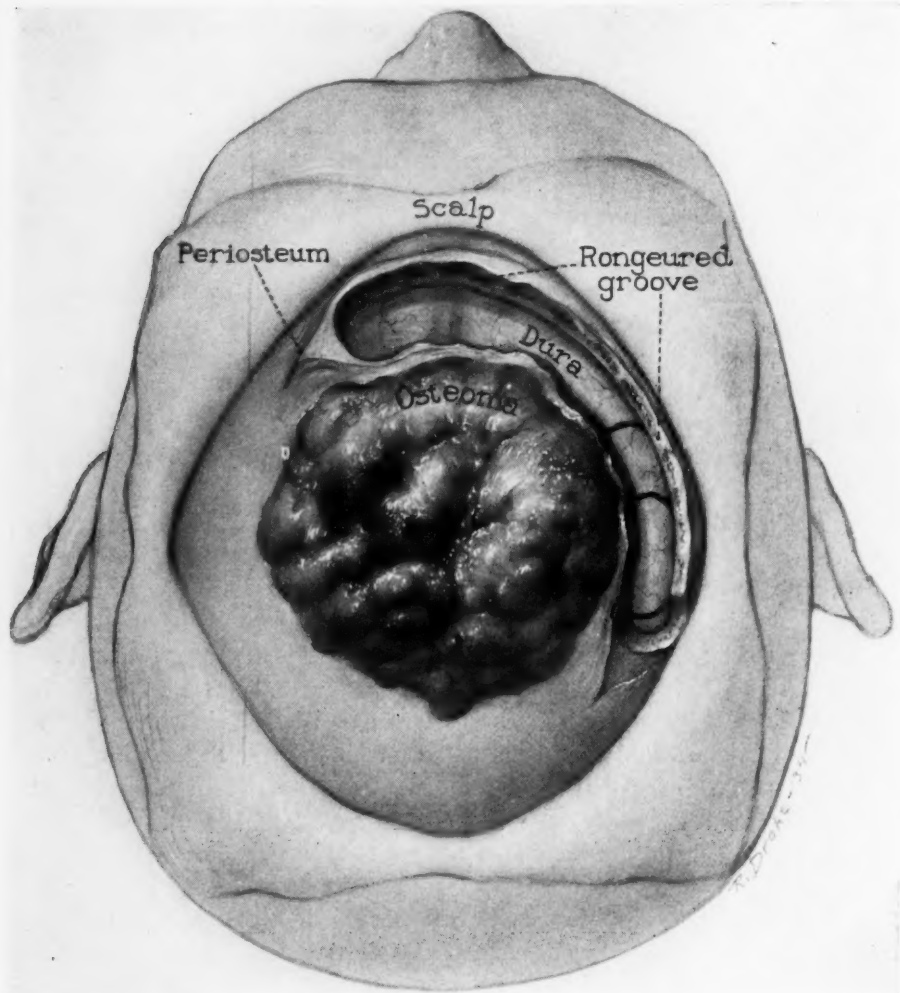


FIG. 5.—Rongeured groove about an osteoma covering a bilateral parasagittal meningioma.

margins of the longitudinal sinus. If one has suspicions that the tumor has extended through the falx to the opposite side, the flap should be extended across the mid-line for five centimetres. The bone flap can still be elevated in one piece, but it is preferable to use eight burr openings, four openings on each side of the mid-line, rather than trying to elevate it with the usual five openings. There is less danger of injuring the longitudinal sinus or of

## OPERABILITY OF BRAIN TUMORS

shortening the distance over the sinus between the burr openings. Therefore, the two openings opposite each other, one on each side of the sinus, in the anterior and posterior limbs of the incision, should be placed just lateral to the sinus. The other two openings on each side are so arranged over the parietal areas to outline a bone flap of appropriate size to permit exposure and removal of the tumor. The bone between the burr openings is sawed on the bevel with a Gigli saw. Extreme care is taken to avoid injury to the longitudinal sinus and communicating veins during the procedure of elevating the bone flap. If the tumor has eroded the overlying skull and osteoma, the bleeding will be excessive and possibly hazardous if one attempts the ordinary bone flap craniotomy. Therefore, I have employed the following technic: The skin flap is reflected independently of the bone in order that the bleeding in the tumor and surrounding skull can be controlled with the electrocoagulation current and bone wax before attempting elevation of the involved bone. The skull block may be removed by one of three ways: (1) by elevating it as one lifts an osteoplastic flap, which is a bloody procedure; (2) by gouging out the soft tumorous portions with the electrosurgical loop and biting away involved bone until normal bone is reached, and (3) by loosening the block of bone by rongeur-ing a groove or trough in the normal bone about the periphery of the osteoma. (Fig. 5.) This allows the surgeon to control the bleeding from bone with wax and gives him an opportunity to ligate vessels on the dura as they are exposed. This procedure not only controls the bleeding from bone, but also diminishes the blood supply to the tumor. It further affords perfect hæmostasis and gradual decompression of the tumor as the dura is incised in the trough about the cerebral tumor. The block of bone may be removed separately or with the cerebral tumor.

If the tumor is a bilateral, parasagittal meningioma, and is situated anterior to the lateral communicating veins, the falx, superior longitudinal sinus, and inferior longitudinal sinus can be resected with the tumor with reasonable safety without producing motor or sensory paralysis. If the tumor is situated posterior to the lateral communicating veins, paralysis will follow if the superior longitudinal sinus is destroyed; therefore, I usually prefer to remove the tumors in this latter group piecemeal, in order not to injure the sinus. It will be impossible to remove all of the tumor-cells by this method, but I believe it to be a wiser procedure, since the result will be an excellent temporary recovery, which may last into years, instead of paralysis. When recurrence takes place, reoperation may afford additional relief.

Tumors arising along the falx or along the inferior longitudinal sinus bulge into the cerebrum and require an incision into the overlying cortex to permit ample exposure for removal with the electrosurgical loop. Care is taken in selecting the area for incision to avoid injuring the motor or sensory cortex. Meningiomas arising on the tentorium, whether they are situated above or below it, should be resected with the tentorium. The lateral sinus can be included with the tumor if the opposite sinus is patent.

The surgeon always has a desire to lift out a tumor with his forefinger in

rapid, dramatic fashion, but unfortunately such a procedure often results in more harm than good, due to the unnecessary injury to the brain and blood-vessels. The proper procedure consists in cautiously elevating the tumor, first by incising the dura along the margins of the meningioma. The incision may be carried completely around the tumor or along the free edge, which is most remote from the sinus. The communicating vessels are controlled with silver clips, or are ligated or electrocoagulated. The over-riding brain and veins are gently elevated and retracted with spatulas. The line of cleavage is maintained by inserting moistened strips of cotton between the cortex and the tumor. The surgical attack is changed from one area to another until the tumor delivers itself. Occasionally, the lateral margin of the sinus may act as a hinge, and when this occurs it becomes necessary to resect a lateral portion of the sinus to include all of the tumor. The edges of the sinus are held compressed with forceps until a running silk suture is inserted. When it becomes necessary to resect one of the large sinuses, it is done by using double strands of silk on an intestinal needle, which allows one to place the ligature through the falx or tentorium below the sinus to fix the ligature thoroughly. Bleeding from the longitudinal sinus is readily controlled by applying pledgets of muscle to the oozing points. Gentle pressure applied to the muscle aids in coagulation and in the effectiveness of hæmostasis. Venous bleeding on cut cortical surfaces is controlled in a similar manner, but all arterial bleeding should be controlled by ligatures, silver clips, or by electrocoagulation. Dural defects and exposed cortical surfaces are usually covered with animal membrane. This membrane is a layer of peritoneum taken from the ox, and it is prepared in a manner similar to that used in the preparation of catgut. It serves as a protection without acting as a foreign body, since it is absorbed much like catgut is absorbed. If the bone flap is preserved, the area adherent to the tumor should be resected, or the entire flap should be boiled for fifteen minutes before being replaced. Bony defects, if small, can be left uncovered, but large defects can be corrected with celluloid plates which are molded to fit the defect and tied to the margins of bone.

Openings made at craniotomy and extending into suboccipital areas are closed in anatomical layers without replacement of bone, since the muscles furnish sufficient support to protect the cerebellum.

*Basal Meningioma.*—These meningiomas have a predilection for the anterior fossa although they do occur in the middle and posterior fossæ. Their behavior is similar to that of tumors which develop along the sinuses, in that they vary in size and structure and produce exostosis in the floor of the skull. Those that develop in the olfactory groove,<sup>10, 11</sup> or in each half of the anterior fossæ, frequently grow to tremendous size before symptoms are observed, since the frontal lobes are capable of displacement. The meningiomas arising on the anterior crest of the sella turcica and sphenoidal wings<sup>48</sup> (Fig. 6) produce visual defects early in their course.<sup>12, 16, 30, 36</sup> Some of these will extend into the orbit and produce proptosis. Meningiomas that develop in the

## OPERABILITY OF BRAIN TUMORS

middle and posterior fossæ produce symptoms corresponding to their anatomical positions.

The surgical attack requires craniotomy suitably placed to give the greatest exposure. The pre-frontal group of tumors may require bilateral craniotomy through a coronal incision in the scalp.<sup>43, 56, 60</sup> The unilateral pre-frontal tumor is exposed best through a Naffziger flap. Tumors of the temporal fossa and sphenoid ridge are most readily exposed through a large, musculo-cutaneous subtemporal decompression craniotomy. Tumors of the posterior fossa are exposed through a bilateral suboccipital craniotomy, whereas those arising from the lateral sinus and tentorium are exposed best through a combination craniotomy, a suboccipital and osteoplastic flap over the occipital lobe.

The electrosurgical unit<sup>12</sup> has contributed more to the treatment of this group of tumors than has any other surgical appliance, since it has made their removal possible. Most of these tumors formerly were considered inoperable,

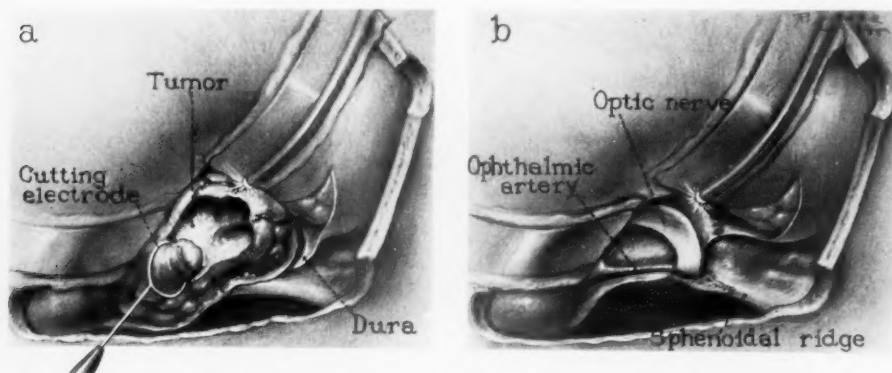


FIG. 6.—(a) Method of removal of a sphenoidal ridge meningioma with the electrosurgical loop, and (b) appearance of structures in the middle fossa following removal of the tumor.

due to their inaccessibility and the inability to control hæmorrhages during attempts at removal by sharp dissection.

Following opening of the skull, the dura is separated from the skull until the margin of the tumor is reached, when the dura is incised about the edge of the tumor. Cotton strips are then placed over the dura but are extended between the cortex and the tumor. Superficial vessels on the tumor are coagulated before the centre is reamed out with the surgical loop. It will be apparent that removal of the centre of the tumor allows the edges to be folded into the cavity. This in turn permits coagulation of more surface and communicating vessels preliminary to removal of more of the tumor. The procedure is repeated until all of the tumor, involved dura, and exostosis have been removed. It is a tedious procedure and requires more time than surgeons would like to take, but it is surprising to see the small amount of shock that occurs when extreme care is taken in the control of hæmorrhage and in the avoidance of cerebral trauma.

Resection of the tip of the right frontal lobe occasionally is necessary properly to expose large basofrontal tumors and tumors of the olfactory

groove. The larger tumors extend across the mid-line and posteriorly into the middle fossa. The inferior longitudinal sinus, along with a portion of the falx, often has to be included in removal of the tumor. Since the left frontal lobe is supposed to contain the psychic centres, precaution is taken to avoid unnecessary handling of this lobe. If the tumor should be situated in the anterior fossa on the left side, a larger bone flap than the usual one is employed to permit greater freedom in elevating the lobe, or a bilateral frontal flap is used in order that the approach may be directed between the frontal lobes.

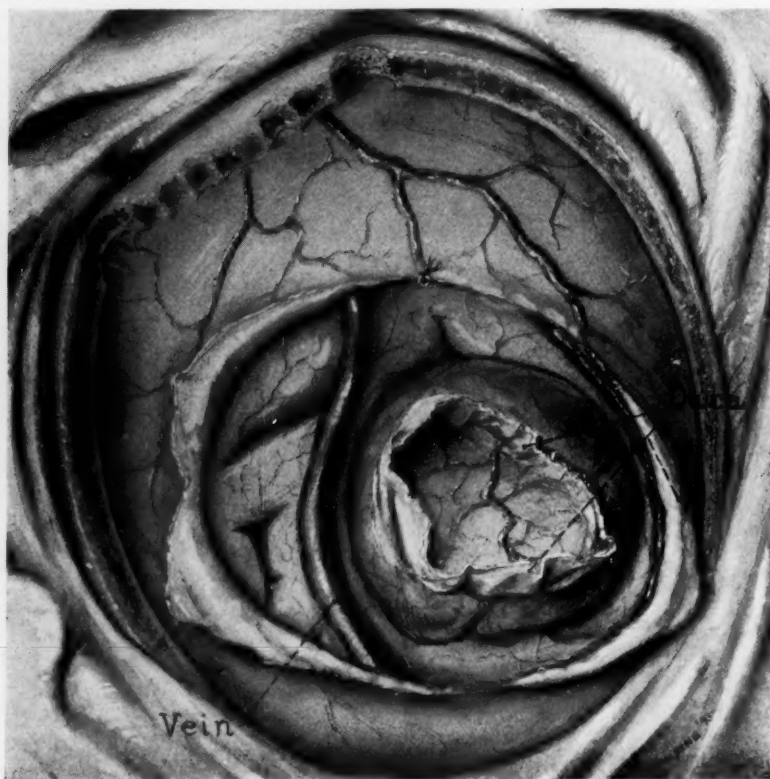


FIG. 7.—Spontaneous elevation of a meningioma following incision of the dura about the tumor.

Resection of temporal and cerebellar lobes occasionally is required to expose thoroughly tumors in the respective positions.

Following removal of the tumor and dura, the exostosis and bone involved by the tumor should be removed in just as thorough a manner as is the osteoma overlying parasagittal tumors. Occasionally this is impossible and, in such cases, the involved bone should be fulgurized with the electrocoagulation current in the hope of further destroying tumor-cells.

There is nothing specific concerning the closure of craniotomy openings following removal of these tumors. Hæmostasis and asepsis must be perfect. A Penrose drain may be inserted into the surgical field between the dura and skull as a precautionary measure, but it should be removed in twenty-four



## OPERABILITY OF BRAIN TUMORS

hours. Collections of cerebrospinal fluid under the flap may require withdrawal through a spinal puncture needle, which is inserted through the scalp just peripheral to the margins of the skin flap.

Results depend on the thoroughness with which the tumor is removed and on the avoidance of cerebral and vascular trauma. Complete cures are obtained. Although most of the meningiomas are benign, recurrence will take place if tumor-cells remain. Since the growth of meningiomas is slow, their symptoms likewise are slow in returning. Occasionally a meningioma under-

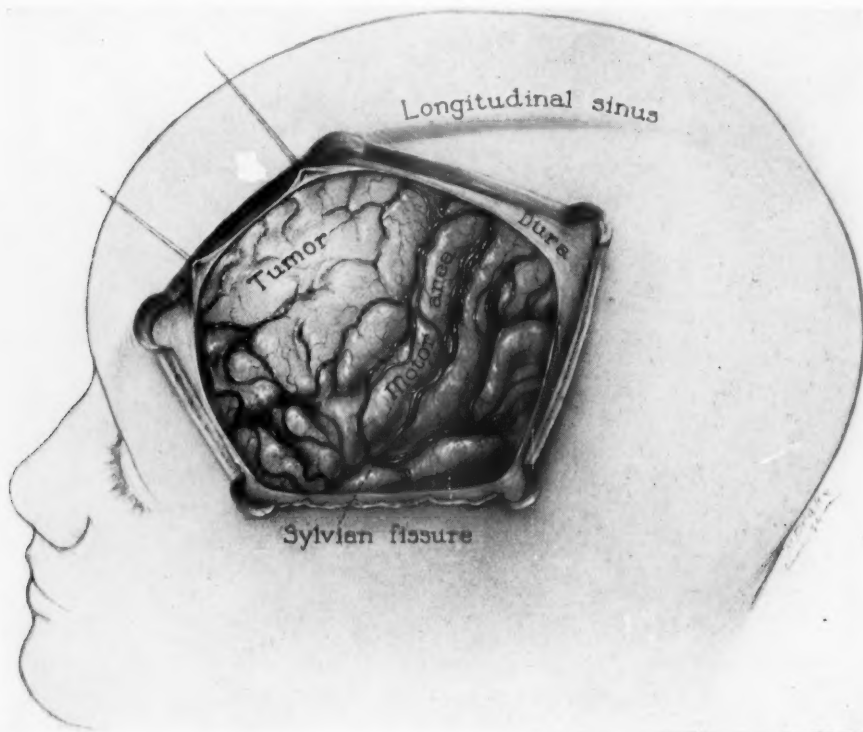


FIG. 8.—Oligodendroglioma situated in the superior and middle convolutions of the left frontal lobe.

goes malignant change and grows rapidly. The flat, sessile tumor, or tumor en plac,<sup>47</sup> is more prone to become malignant than the lobulated, rounded tumor.

Meningiomas that develop on the surface of the hemispheres and cerebellar lobes represent the smallest group of encapsulated tumors. They also represent the most successful group surgically, since they are most accessible and operable. The methods of exposure and removal are similar to those employed in the treatment of parasagittal meningiomas. These tumors deliver themselves as soon as the dura is incised about the periphery of the tumor. (Fig. 7.) Precaution again should be employed to avoid unnecessary trauma to cerebral vessels and cortex.

*Glioma.*—Pathologically,<sup>2, 52, 53</sup> gliomas are classified according to their

histological structure and degree of malignancy. Surgically, they are grouped according to accessibility and degree of malignancy. Those which are situated wholly within the silent areas are removed with the surrounding brain. Those which are situated in such areas as the occipital lobes, post-central areas, or in the cerebellar lobes, can be resected with the surrounding brain without seriously incapacitating the patient. Those which are situated in the motor cortex require more conservative treatment, such as subtotal resection from within the tumor, to avoid increasing the existing motor disturbances. Resec-

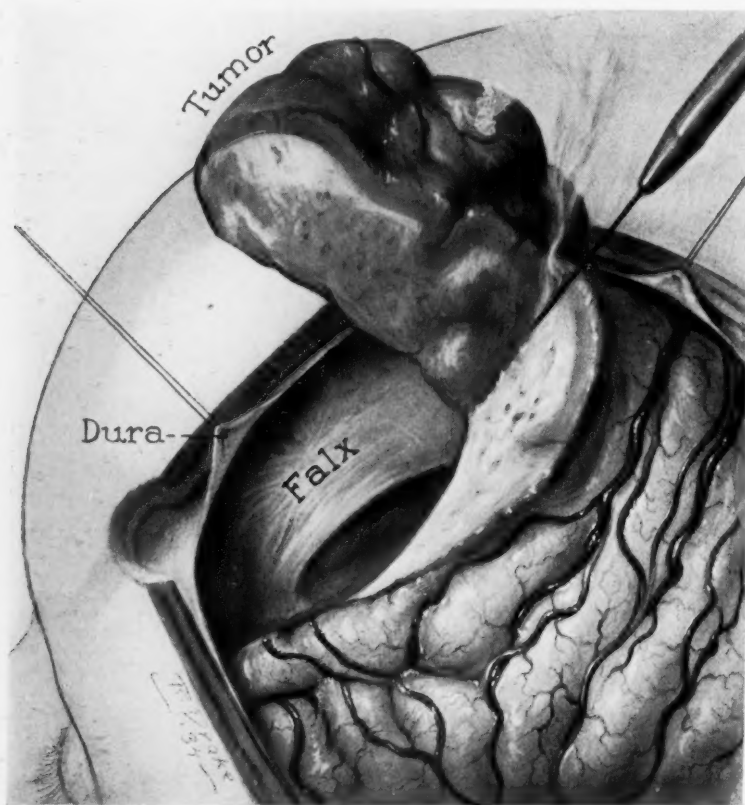


FIG. 9.—Removal of the oligodendroglioma shown in Fig. 8.

tions of cerebral hemispheres have been performed, but these procedures should be limited to a small group, since a tumor that requires such radical resection usually has invaded the basal ganglions and, unless they also are resected, removal is incomplete. Furthermore, I doubt if many patients would appreciate the extended period of life if they knew that they would suffer from spastic, partial or complete, hemiplegia for their remaining years. Deeply placed subcortical tumors involving basal nuclei are situated beyond the reach of the surgeon.<sup>58</sup>

Lobectomy and block resection of tumors are performed by dissection with the sharp knife or the electrosurgical knife. Bleeding is prevented by electro-

## OPERABILITY OF BRAIN TUMORS

coagulation of the vessels. All large vessels are more securely controlled when ligated with silk ligatures. The electrosurgical knife produces more destruction than the scalpel; therefore, it should be used only when the scalpel fails to serve its purpose.

*Oligodendroglioma and Astrocytoma.*—These tumors (Figs. 8, 9 and 10) represent the most benign types of glioma. They grow slowly and often degenerate in the centre. The astrocytoma may degenerate to such an extent that nothing remains but a mural nodule. (Fig. 11.) Following evacuation of the cystic content, which consists of yellow, syrupy fluid that coagulates on exposure to air, the mural nodule often can be removed completely and cure thus effected. These tumors occur in all parts<sup>28</sup> of the brain and at all ages, although they occur in the cerebellar lobes<sup>13</sup> and vermis more frequently before the age of fifteen years than they do after that age.<sup>22</sup>

*Angioma.*<sup>15, 19</sup>—These tumors are moderately well circumscribed and frequently are situated so that subtotal or total removal may be accomplished.

*Spongioblastoma Multiforme.*<sup>21</sup>—These tumors represent the average malignant type of glioma.

They grow rapidly, are very vascular, and have less tendency to degenerate and become cystic. Their total removal depends on their being situated in an area, tissue of which can be resected with the tumor.

*Medulloblastoma.*—Medulloblastomas represent the most malignant group of all gliomas. They cannot be enucleated, and the only hope of removing them depends on their being situated in a silent area of the brain. Partial resection occasionally is advisable when the tumor obstructs the fourth ventricle.



FIG. 10.—Appearance of patient three weeks after removal of oligodendroglioma shown in Figs. 8 and 9.

*Acoustic Neuroma.*—These tumors develop within, or from the neural sheaths of, cranial nerves. Acoustic neuromas grow slowly, and most of them undergo fatty degeneration in one part while growth continues in another part. If the tumor was always recognized early, it could be removed *in toto* by sectioning the nerve on each side of it; but, unfortunately, it is rarely diagnosed until it has eroded the internal auditory meatus and has indented and displaced the pons and the overlying cerebellar lobe. Associated with the growth of the tumor is an increased blood supply and numerous adhesions. Other cranial nerves are often displaced and may be found passing over the surface of the tumor, all of which complicates its free removal. An attempt to deliver the tumor by evulsing the eighth nerve too often gives rise to uncontrollable hæmorrhages and to injuries to the ninth and tenth cranial nerves and to the pons to adopt such a procedure universally.

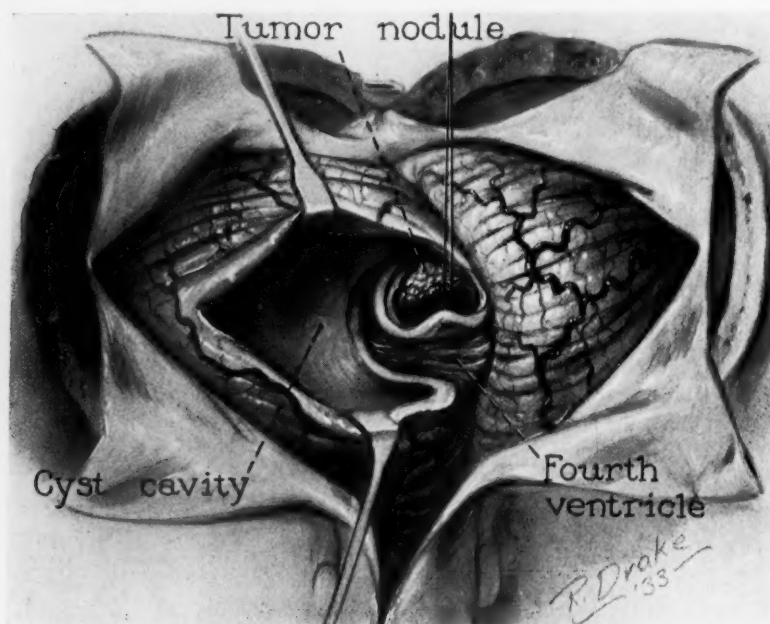


FIG. 11.—Method of removing a mural nodule in a cerebellar astrocytoma.

The safer operation is intracapsular enucleation through a wide bilateral suboccipital craniotomy opening. (Fig. 12.) The cerebellar lobe is either elevated or partially resected and then elevated preliminary to the attack on the tumor. The cortex is protected with strips of cotton and then lifted gently from the tumor with an illuminated ganglion retractor. Vessels running on the surface and vessels communicating with the tumor are coagulated preliminary to incisions into the tumor. The lateral half of the tumor is exposed and removed with the electrosurgical knife, after which the intracapsular content is removed piecemeal, using a curet or the electrosurgical loop. As much as possible of the capsule is removed without disturbing the

## OPERABILITY OF BRAIN TUMORS

circulation on the pontine side. Bleeding within the capsule is controlled by electrocoagulation or by the use of pledgets of muscle.

The results following intracapsular removal are very satisfactory when fatty degeneration is found to be far advanced, but recurrences do take place and do so more frequently when fibroblastic cells predominate. Intracapsular enucleation in conjunction with suboccipital decompression will give permanent relief in the group of cases in which tumors have undergone degeneration and will give relief for five or ten years in the group of more actively growing tumors. Therefore, I believe that the intracapsular method is the one of choice, since it is attended with less surgical risk and less likelihood of permanent injury to the ninth and tenth cranial nerves.

*Tumors of the Ventricles.*—Ventricular tumors<sup>4, 5, 6, 17, 54, 57</sup> arise from the choroid plexus and ependyma, but they may arise from adjoining cerebral

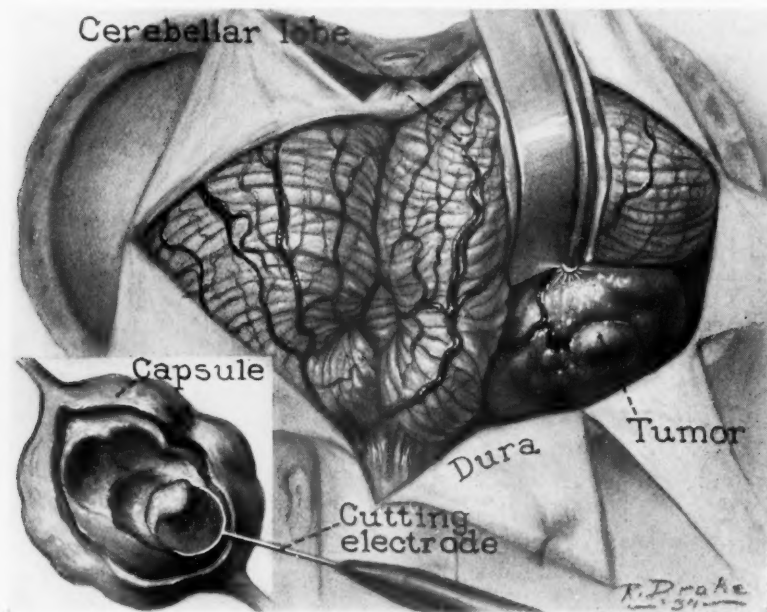


FIG. 12.—Method of exposure of, and intracapsular enucleation of, an acoustic neuroma.

structures and bulge into the ventricular system. Tumors originating in the choroid plexus and ependyma frequently are pedunculated cysts and papillomas and permit of complete removal, whereas those developing from the brain and extending into the ventricle are sessile, gliomatous and rarely are operable.

Tumors of the lateral ventricle are not easily recognized clinically. The routine röntgenogram will visualize calcareous lesions of the choroid plexus, but it usually requires a ventriculogram to determine the situation and size of the tumor. These tumors are exposed through a frontal cortical incision which passes through the mid-frontal convolution into the ventricle. The



posterior horn of the lateral ventricle is explored through a cortical incision placed posterior to the sensory convolution.

Pedunculated tumors are resected with the aid of the electrosurgical knife and the coagulation current. One has no hesitancy in resecting a choroid plexus. Tumors that extend into the ventricle from surrounding brain tissue lend themselves poorly to surgical treatment. A portion of the tumor may be removed, but not enough is accomplished to justify the procedure.

Tumors of the third ventricle are very similar in type to those which develop in the lateral ventricles, except that they produce rapid progression of internal hydrocephalus, inasmuch as they block the normal flow of cerebrospinal fluid. They are less accessible than tumors of the lateral ventricle. The best approach is through a dilated lateral ventricle. The right side is preferable to the left because the psychic and speech centres are situated in the left frontal lobe and in the left island of Reil, respectively. The third ventricle is entered after dividing the septum pellucidum. Again, pedunculated tumors and cysts are the only tumors that are removable.

Tumors of the fourth ventricle, like other ventricular tumors, arise from the choroid plexus, ependyma, and such surrounding tissues as the nuclei, peduncles, and vermis. Pedunculated and circumscribed tumors are resectable, as are some tumors of the vermis, but removal of any tumor of the fourth ventricle is a hazardous procedure and requires the most delicate manipulation. Tumors that bulge into the fourth ventricle from the cerebellar lobe may be removed when the cerebellar tissue can be included with the tumor. Tumors that grow from the floor of the ventricle are difficult to manage, and the most that can be accomplished surgically for them is a decompression that includes bilateral suboccipital decompression with longitudinal incision of the vermis. The decompression should include removal of bone from the posterior margin of the foramen magnum and from the dorsal fifth of the atlas, further to relieve pressure about the medulla from the prolapsed cerebellar lobes. Occasionally, subtotal resection of the tumor is performed to relieve the obstruction at the lower end of the aqueduct.

*Pituitary Tumors.*<sup>29, 32, 37, 59</sup>—Pathologically, these tumors too are classified into numerous groups, but surgically they fall into two groups: those that are accessible and removable and those that are non-accessible or are malignant. Pituitary tumors invariably erode<sup>23</sup> the sella and the clinoid processes, but sooner or later they grow beyond the sella. The adenomas usually extend upward and backward between the optic nerves and under the chiasm and produce the typical bitemporal hemianopia with optic atrophy. As the growth continues or becomes cystic, it extends laterally under the optic nerves and vessels, or it may grow upward and then over the chiasm under the temporal lobes or into the third ventricle by displacing the floor upward and blocking the foramina of Monro, giving rise to internal hydrocephalus, choked disks, loss of nasal fields, and complete amaurosis.

The transnasal approach has practically been abandoned for the transfrontal, intradural or extradural approach, since the latter approach is

## OPERABILITY OF BRAIN TUMORS

through a sterile field and offers a greater opportunity thoroughly to remove suprachiasmal tumors as well as to enucleate intrasellar growths.<sup>36</sup>

Surgical attack on pituitary tumors has been limited to neoplasms that produce visual disturbances. Unless the symptoms have progressed to this degree, due to lateral displacement of optic nerves and posterior displacement of the chiasm, the optic chiasm rides so closely to the anterior crest of the sella that it is impossible to enter the sella without injuring the optic nerves. Attempts have been made to resect the pituitary gland in cases of acromegaly in which patients have had no visual disturbances, but this has been unsatisfactory for the same reason. Radium seeds have been planted into the gland with success through the limited opening between the optic nerves.

The accepted approach is through a right transfrontal craniotomy opening. The frontal lobe is elevated,<sup>46</sup> and the dura is separated from the bone in the anterior fossa. The dissection is continued posteriorly to the wing of the sphenoid and mesially to the mid-line. The dura is then incised on the anterior crest of the sella, and the incision is extended laterally for two centimetres along the wing of the sphenoid and, anteriorly, parallel with the falx for three centimetres in order adequately to expose the chiasmal structures. The frontal lobe is protected with cotton strips before it is gently elevated with an illuminated spatula-like retractor. The greatest of precaution is employed in exposing the tumor. Cotton pledgets and packs are used to protect the optic nerves and chiasm. Vessels on the capsule are coagulated before the capsule is incised. The intracapsular content is removed by the use of curets, pituitary forceps, blunt dissection with a cotton ball held with a bayonet forceps, and with an aspirator. Following removal of the tumor, the capsule is gently dissected free from optic nerves and vessels and retracted into the pre-chiasmal space where it is resected, thus leaving only that portion which is adherent in the floor of the sella. Intracapsular bleeding is controlled by cotton tampons or by the application of silver clips or by coagulation of bleeding points under direct visualization. Pledgets of muscle may be used to control venous oozing. The craniotomy opening is closed as previously described.

The results again depend on the thoroughness of the operation, the avoidance of trauma and on the pathological structure of the tumor.

*Pineal Tumors,*<sup>34</sup> *Cholesteatomas*<sup>39</sup> and *Dermoids.*<sup>35</sup>—These and other unusual tumors<sup>44</sup> are explored and resected according to their position and structure. If encapsulated, they are treated as meningiomas. If non-encapsulated, they are treated in a manner similar to that for gliomas.

**INOPERABLE TUMORS.**—Inoperable tumors developing in or involving the corpus callosum, basal nuclei, brain stem, pons and medulla, present difficult surgical problems, since their removal is impossible and little or no relief is accomplished with decompressions. Since many of these tumors are of the variety known as medulloblastoma and spongioblastoma multiforme, radiotherapy offers temporary relief. High-voltage Röntgen-ray therapy is the most suitable type of treatment for adults who will coöperate, since it can be

administered in massive doses over a short period. Radium is most suitable in the treatment of similar lesions among children and non-coöperative patients, since the blocks of radium can be bandaged on the heads of the patients. It should always be remembered that the application of radiotherapy may increase the symptoms for the first ten days due to swelling and œdema of tumor-cells. This may require dehydration, a treatment which consists of limitation of fluids, diuretics, saline cathartics and enemas, and intravenous administration of hypertonic solutions of glucose and sodium chloride.

*Metastatic Tumors.*<sup>7</sup>—These usually are multiple and frequently are associated with other manifestations of metastasis. The removal of a single large nodule may give temporary relief, but it is doubtful if surgical intervention is justifiable. Decompressions are occasionally resorted to, but the relief obtained again is of such short duration as scarcely to justify the procedure. Treatment with Röntgen-rays occasionally gives temporary relief; therefore, a therapeutic test may be indicated.

**DECOMPRESSIONS.**—Decompressions placed at the base of an osteoplastic flap under the temporal muscle are worth-while in offering additional relief in the management of subtotally resected tumors and with tumors that are inoperable which involve the cerebral hemisphere. Decompressions placed over inoperable tumors result in ugly-appearing hernias, and should be employed only when the patients and relatives are thoroughly informed concerning the temporary relief and subsequent appearance of the hernia.

Large subtemporal decompressions occasionally are indicated for a moribund hemiplegic patient when the patient's general condition is too critical to warrant an osteoplastic flap craniotomy.

If a tumor has been located beyond reach of the exposure at the time of operation, the decompression will give sufficient temporary relief for the patient to improve and be prepared for an osteoplastic flap craniotomy.

All suboccipital craniotomies are in reality suboccipital decompressions, since the bone is rarely elevated as a flap but is removed with a rongeur and is never replaced during the closure. The muscles, fascias, and scalp are closed in anatomical layers. The dura may also be resutured but, more often than not, it is allowed to lie loosely over the cerebellar lobes. To make the suboccipital decompression most effective, occipital bone should be widely removed and be made to include the bone in the dorsal portion of the foramen magnum and in the dorsal arch of the atlas. I wish to emphasize again that decompressions should not take the place of radical removals of tumors, but I do believe they serve as adjuncts in the treatment of subtotally resected tumors and offer sufficient temporary relief in selected cases of inoperable tumor to warrant their use.

**SUMMARY.**—The object of this discussion has been to review the changes which have taken place in the management of brain tumors and to record opinions relative to their operability.

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## PHYSIOLOGICAL CONSIDERATIONS RELATED TO THE INFUSION TREATMENT OF SHOCK\*

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IN A discussion of shock it should not be thought of as an entity or as belonging to any particular field of medicine. It is most often seen in surgical practice but may be encountered in some form in all branches of medicine. Atchley<sup>1</sup> has called attention to the occurrence of shock in purely medical conditions such as diabetic acidosis, in certain pneumonias, and in diarrhoeal diseases. Furthermore, there are many shock-like conditions which so closely resemble the classical picture that they must be included under that heading. A patient with a severe general peritonitis, for example, may present physical signs which are not easily distinguished from those of traumatic shock. If we bear in mind that severe trauma may be inflicted upon the body by certain bacteria, by chemical poisons, by privation and in many ways other than mechanical, the widespread possibilities of shock are recognized. The involved nature of the condition precludes definition since it is obviously impossible to contain in a simple phrase the collective physiological changes that occur. The subject is further complicated by the fact that there are two principal types of shock, primary and secondary, which present somewhat similar pictures but which are physiologically different.

Primary shock is the type which immediately follows an injury and may exist in any degree from slight syncope to the most profound collapse. When associated with important loss of blood its explanation is simple. On the other hand severe primary signs may follow an injury in which no direct loss of blood has occurred. It is perhaps best explained on the theory of suppressed innervation with reflex general atony which especially affects the cardiovascular system. The circulation of the blood is greatly influenced without any actual loss of volume.

Secondary or delayed shock on the other hand presents several features which are different from the primary type. Its onset may be actually delayed or it may immediately follow and be continuous with primary shock. Prior to the World War the physiological concept of the condition, at least in this country, was an inhibited or exhausted vasomotor mechanism with a transfer of blood to the venous side notably to the large venous trunks, as suggested by Crile.<sup>2</sup> The absence of a large part of the blood volume from circulation was explained in this way. This theory was disturbed by the

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\* Read before the New York Surgical Society, January 10, 1934.

## INFUSION TREATMENT OF SHOCK

fact that, during the war, surgeons operating upon patients in shock found the larger veins empty, or nearly so. This called for a restudy of the condition and the British Medical Research Committee conducted a series of investigations. Their work revealed a significant diminution of the blood volume and at the same time a concentration of stagnant corpuscles in the capillaries. It was furthermore found that the vasomotor mechanism was capable of response if supplied with a sufficient circulating medium. As the result of these findings the theory of secondary shock was revised. The diminution of blood volume was attributed to general loss of plasma through capillary walls rendered abnormally permeable by some toxic product of protein decomposition, such as histamine.<sup>3</sup> This theory seemed to offer a satisfactory explanation for the diminished blood volume and for the concentration of corpuscles in the capillaries.

More recent studies upon the exchange and metabolism of fluids in the body, however, have again raised the question as to what becomes of the fluid which all are agreed leaves the circulatory channels and as to the mechanism of its escape. When actual hæmorrhage is excluded, the present tendency is to account for the depleted blood volume as being the result of local loss of plasma due to capillary damage in the field of trauma.

Blalock<sup>4</sup> with his co-workers in a series of experimental studies has observed significant accumulations of blood and local losses of plasma in the traumatized areas. By comparing the weight of the crushed extremity of a dog with that of the normal extremity, for example, he has been able to account for local losses of plasma which seemed sufficient to explain the fall in blood-pressure and the other manifestations of shock. Experiments in which shock was induced by manipulation of the intestines resulted in extensive local exudation and congestion. In general, Blalock does not think that it is necessary to assume an increased permeability of the capillaries to account for the depleted blood volume. He feels that the tissue fluid filtering into the capillaries in the normal way fails to restore blood volume because its entrance tends to raise capillary pressure and results in further loss of plasma at the site of injury. This loss of plasma reduces the osmotic pressure of the blood and diminishes its ability to attract water from the tissues. Underhill<sup>5</sup> and his associates also have observed extensive local losses of fluid in burns, in poisoning by lethal war gases and in influenza. All of these conditions produce shock-like states. In experimental work of the kind described there can be little doubt but that regional loss of plasma is important in the production of shock. In certain types of clinical trauma, including operative work, it must also have its influence.

Another factor which contributes to the development of secondary shock and one which we feel has not received the attention which its clinical importance calls for is dehydration. As related to shock it may be said that in studies of dehydration and of shock increased concentration of the blood has been a regular finding. Cannon<sup>6</sup> and his associates in their work on traumatic shock consistently noted it. In observations on dehydration Keith<sup>7</sup>

MACFEE AND BALDRIDGE

and Marriott<sup>8</sup> found the same condition and Marriott has referred to it as anhydræmia. Both have called attention to a striking similarity in the two conditions. The investigators of the World War era apparently did not take seriously into account the effects of general dehydration though it must have been almost universal with soldiers in action.

Studies on water metabolism reveal to what extent dehydration may develop within a few hours. According to the determinations of Benedict and Root<sup>9</sup> and of Newburgh<sup>10</sup> and his associates the insensible loss of water by way of the lungs and skin in an average adult ranges from 600 and 1,550 cc. per day depending upon whether the subject is at rest or engaged in normal activity. Collier and Maddock<sup>11</sup> have shown that the average patient loses

TABLE I  
Total Weight Loss Following Operations

*Calculations based on averages of the number of cases indicated*

<i>Tonsillectomy 19 Cases Ether Anesthesia</i>	<i>Weight before Operation Grams</i>	<i>Fluid Intake cc.</i>	<i>Weight plus fluid Intake Grams</i>	<i>Weight at end of 24 hrs. or be- ginning of post-op 24 hrs. Grams</i>	<i>Weight at end of 24 Post-OP 24 hrs. Grams</i>	<i>Net Loss of Weight Grams</i>
<i>First Post-operative 24 hours</i>	57,727	2,490	60,217	56,364		3,853
<i>Second Post-operative 24 hours</i>		2,610	58,974	56,364	55,455	3,520
<i>Mastoidectomy 2 Cases Ether Anesthesia</i>						
<i>First Post-operative 24 hours</i>	20,227	1,860	22,087	19,545	2,542	2,542
<i>Second Post-operative 24 hours</i>		1,380	20,925	19,318	1,607	1,607
<i>Operations about face and neck for cancer. Colonic Ether Anesthesia. 6 Cases</i>						
<i>First Post-operative 24 hours</i>	65,909	865	66,774	63,786		2,988
<i>Second Post-operative 24 hours</i>		2,555	66,341	63,786	63,027	3,314

about a litre of fluid during operation and in the four hours after. Extending their observations over a period of days they found<sup>12</sup> that the insensible water loss of the sick surgical patient averages roughly 2,000 cc. per day. To this they add 1,500 cc. of water needed to provide a urinary output of a specific gravity not exceeding 1.015. After fluid losses from the gastro-intestinal tract are provided for it is seen that the basic fluid requirements of the ill, surgical patient are between 3,000 and 4,000 cc. per day. The net loss of weight recorded in a series of patients operated upon at St. Luke's Hospital and at the Stuyvesant Square Hospital confirm in a general way the findings of Collier and Maddock. (Table I.) The tonsillectomy cases showed rather striking loss although this operation is regarded as a minor one. The amount of fluid lost following operation amounts each day to more than half the equivalent of the total blood volume. It is not surprising that this loss, if not replaced, should bring about a reduction of the fluid elements of the blood.

## INFUSION TREATMENT OF SHOCK

In addition to the usual post-operative loss of fluid there may be wastage of an extraordinary character. Rowntree<sup>13</sup> has assembled figures which indicate that the amount of fluid normally secreted into the gastro-intestinal tract daily is from 7,500 to 10,000 cc. The greater part of this is reabsorbed. If, however, some pathological condition, such as intestinal obstruction, fistula, or peritonitis interferes with reabsorption, a deficiency of water is rapidly brought about. The importance of loss of gastro-intestinal fluids is increased by the fact that the water element carries with it materials, chiefly fixed base and chloride ion, which support body fluid and blood volume. Gamble and McIver<sup>14</sup> have shown that the gastric, pancreatic, hepatic, and jejunal secretions closely parallel the blood plasma in content of water, and fixed base—mainly sodium, and chloride.

From the above discussion we have seen to what extent dehydration may progress in a relatively short time. A deficiency and concentration of the circulating blood volume develops and we may have the classical signs of shock. It is not to be inferred, however, that dehydration invariably leads to this state.

There can be no question but that important losses of fluid are as a rule well endured by surgical patients. After a day or two of progressive dehydration they begin to take water and the deficit is made up. On the other hand certain patients by reason of severe operation, loss of blood, or other causes fail to manifest this recuperative ability. Some are unable to take sufficient water or unable for some reason to retain it. When signs of shock are exhibited there should be an accounting of water supply based upon the estimated fundamental requirements of the patient plus the extraordinary losses. If a shortage is found it should be made up as promptly as possible. The obvious treatment is an adequate amount of water in a form which favors its retention. Normal salt solution by the intravenous route is simple and usually effective. Its efficacy and mode of action is better understood if we review some of the physiological principles underlying the distribution of water in the organism.

The ultimate contact of the blood-stream with the body cells is made by the capillaries. Through the walls of these microscopical channels exchanges of water, chemical and nutritious substances take place. These exchanges are conditioned in large measure by the well-known physical laws of filtration, diffusion, and osmosis. These laws are modified to some extent by the facts that the capillary wall is a living membrane, that it is much thinner than any which may be used in laboratory experiments, and that it exhibits selective permeability. For example, it is readily permeable to soluble crystalloid substances but under normal conditions it is relatively impermeable to the colloid proteins. Dissolved crystalloid substances, such as sodium chloride, may therefore pass through it in either direction with little interference whereas the passage of protein as such is inhibited.

Under normal conditions according to Cannon<sup>15</sup> the tissue cells through medium of the intercellular fluid, or tissue lymph tend to remain in a state



of fluid and chemical balance with the blood plasma. It was Starling's<sup>16</sup> view that this balance is maintained through equality of the two principal forces involved, namely, hydrostatic pressure and osmotic pressure acting on the two sides of the dividing capillary wall. It is modified temporarily by metabolic processes but resists anything like a permanent change. It is only by keeping in mind this relative immutability that some of the normal processes concerned with the interchange of water and substances in solution are made clear. At the same time it enables us to visualize the readjustments which follow such upsets as hæmorrhage and dehydration, both of which intimately concern us in shock.

If any considerable change in the pressure relationships between the blood and the tissues is brought about, a movement of fluid is set up and its direction will be toward the side of the least total pressure. The osmotic pressure within the capillaries is largely maintained by the plasma proteins to which the capillary walls are said to be normally impermeable. Fluid movement into or out of the capillaries therefore takes place when the intracapillary hydrostatic pressure falls below or rises above the protein or colloid osmotic pressure of the plasma.

In the case of hæmorrhage according to the above principle fluid should flow from the tissues through the capillary walls into the blood-stream. It has long been known that such a flow does take place and that the normal blood volume is restored within a short time. Adolph<sup>17</sup> and his associates have recently shown from the plasma dilution curves that restoration of blood volume after acute hæmorrhage in dogs takes place at the remarkably rapid rate of 0.25 cc. per Kg. of body weight per minute. If we may translate this finding into human terms a man weighing 72 Kg. (approximately 158 pounds) should regain his blood volume at the rate of about 40 cc. per minute, or 2,400 cc. per hour. We cannot, of course, assume a direct parallelism but it is likely that restoration of blood volume by tissue fluids occurs much more rapidly than we might suspect. In dehydration it is believed that the water gradually being lost from the blood-stream is likewise made up from the tissue reserve stores. In either case it is obvious that available fluids must be in the tissue spaces if the circulatory deficit is to be met in this efficient manner.

When, on the other hand, a surplus of fluid is created in the blood-stream, as by excessive ingestion of water or by intravascular injection, pressure relationships are set up which are just the reverse of those found in hæmorrhage. The result is a passage of the filterable elements from the blood into the tissues.

The rate of this flow may be very rapid. Boycott<sup>18</sup> without previously bleeding the animals, injected Ringer's solution into the jugular veins of rabbits in amounts equivalent to the estimated blood volume. The total amount was injected in five minutes. Tests for dilution of the blood taken at five-minute intervals afterward showed that normal volume in the case of healthy animals was restored within twenty-five minutes. Sixty-seven per

# INFUSION TREATMENT OF SHOCK

cent. of the fluid escaped within the short period of injection, that is, within five minutes. Smith and Mendel<sup>19</sup> who also used rabbits injected equivalent amounts in the space of two minutes and obtained results closely corresponding to those of Boycott. None of the animals developed œdema, nor pleural effusion. There was never more than 5 cc. in the peritoneal cavity. Only about 9 per cent. of it could be accounted for in the urine. There appeared to be some increase in the water content of the gastro-intestinal tract.

The question as to what becomes of the fluid which escapes from the blood-vessels under such conditions has been answered rather satisfactorily by the earlier experiments of Engels.<sup>20</sup> This investigator using dogs which had been deprived of food and water for four days injected normal salt solution into the jugular vein at the rate of 3 cc. per Kg. of body weight per minute, the average dose being 1,159 Gm. Three hours after the injection the dogs were killed and by comparing them with control animals which had not been injected Engels attempted to determine the tissue distribution of

TABLE II

*Infusions of 2000 to 5000 Cubic Centimetres of Physiological Saline Average 3500 cc.*

Average of →	Red Blood Cells 9 Cases	Hæmoglobin 9 Cases	Ratio of Red Blood Cells to Plasma 9 Cases	Platelets 6 Cases	Bleeding Time 5 Cases	Coagulation Time 5 Cases	Prothrombin Time 5 Cases	Total Protein Grams per 100 cc. 5 Cases	Fibrinogen Grams per 100 cc. 5 Cases	Non-protein Nitrogen mgm. per 100 cc. 4 Cases	Plasma Chlorides Gms. per 100 cc. 7 Cases	Calcium mgm. per 100 cc. 5 Cases
Before Infusion	4,133,000	75	0.425	262,500	2.0 min.	3.8 min.	6.0 min.	6.11	.68	60.6	5.78	12.0
After Infusion	3,552,000	67	0.5	267,000	1.7 min.	2.6 min.	5.75 min.	4.81	.50	51.2	6.32	10.5

the injected fluid. He found some increase in water content of all the tissues except bone, but by far the greatest reservoirs were the muscles and skin. The muscles which constituted about 40 per cent. of the body weight accommodated 60 per cent. of the added fluid and without impairment of their function.

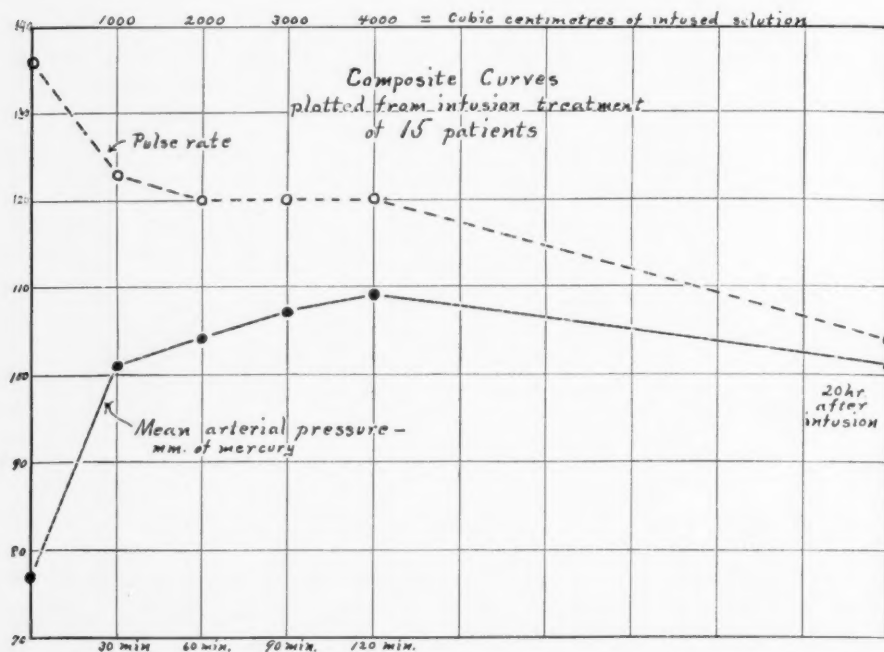
Similarly in human beings, if we may judge by such indications as red-cell counts, hæmoglobin determinations, ratio of red cells to plasma, and protein content taken before and immediately after large infusions with normal saline no great dilution of the blood occurs. (Table II.) Since only a relatively small part of it can be accounted for in the urine it seems proper to assume that a large part of the fluid is stored in the tissue reservoirs. It does not, however, show evidence of its presence by producing œdema, unless repeated large infusions are given.

Further evidence that surplus fluid is taken up from the blood-stream is found in the behavior of the arterial blood-pressure curve during infusion. (Chart I.) It will be seen in cases of shock that the curve rises rapidly with the introduction of fluid until a level corresponding to the average normal is reached. As more fluid is infused the curve usually continues to rise but much more slowly. Frequently, however, it does not go beyond the normal

for the individual and it rarely exceeds the normal by more than 20 mm. of mercury. The fluid injected if in the form of normal salt solution is retained by the tissues and gradually finds its way back into the blood-stream as it is needed. Any excess beyond tissue saturation is disposed of by the kidneys.

Fear of overburdening the heart with large doses of physiological saline does not seem well founded. Instead of showing signs of strain the heart shows evidence of improvement. The rate is slowed (Chart I) and the pulse changes from a rapid, thready character to slower rate with full volume. The improved heart action is probably due in part to the fact that the

CHART I



ventricles in diastole are more completely filled and the muscle fibers are lengthened. The chambers of the heart can dilate only as there is fluid to fill them. Starling<sup>21</sup> and his associates have shown that the energy of contraction of heart muscle, like skeletal muscle, is increased by lengthening its fibers. The more completely the ventricles are distended, therefore, within limits, the greater their length of muscle and the more efficient their contractions. Complete diastole and elevated blood-pressure, moreover, combine to improve the coronary circulation. How far we are from overburdening the heart will be realized when we calculate the actual amount of infused fluid the heart is called upon to take care of. When introduced at the rate of 2,000 cc. per hour, it will be seen that a heart beating at the rate of eighty-five per minute would be required in the beginning to accommodate less than 0.5 cc. or about six drops of additional fluid at each systole. By the time the fluid is returned to the heart all but a small fraction will have been absorbed by the

# INFUSION TREATMENT OF SHOCK

tissues. If we bear in mind that the blood dilution never reaches more than a relatively small part of the initial blood volume it is apparent that the average heart which is capable of increasing its output manyfold<sup>22</sup> is in no danger of becoming overburdened within the limits indicated. It may also be stated as a corollary that with a compensated heart pulmonary œdema is not to be seriously considered.

Another possible consequence of large infusions to be thought of is the effect on coagulation of the blood. The elevation of blood-pressure and the moderate dilution of blood might reasonably be expected to favor hæmorrhage. As a matter of fact, however, an infusion with salt solution given during an operation, radical mastectomy, for example, produces little if any increase in bleeding. Comparisons of coagulation time done before and after infusion have as a rule shown a shortening of the time after infusion.

TABLE III  
*Bleeding Before and After Saline Infusion (Rabbits)*

Animal Number	Weight in GRAMS	Infused Saline Solution cc.	Bleeding time before Infusion, minutes	Bleeding time after Infusion, minutes	Coagulation time before Infusion, capillary Submethod	Coagulation time after Infusion, minutes	Blood lost before Infusion cc.	Blood lost after Infusion cc.	Remarks
A-94	2850	142	2.25	1.5	Not done	Not done	1.5	1.0	Recovered
A-91	2300	115	12.5	7.0	"	"	38.0	14.0	"
A-97	2500	125	7.0	6.25	"	"	28.0	16.5	"
A-88	1500	75	3.5	3.5	"	"	1.5	.5	"
A-89	2300	115	15.0	6.0	4.5	3.5	26.0	10.0	"
A-90	1800	100	7.0	8.0	6.0	4.5	4.0	15.0	Animal had fungoid disease of ears. Died within 12 hours
A-93	1840	95	8.0	12.0	2.5	4.5	2.0	15.0	Recovered
A-92	2600	130	46.0	9.5	2.0	3.5	70.0	7.0	Primary hæmorrhage was 2.7% of body weight. Signs of hæmorrhage disappeared after infusion. Recovered.

To test this result by animal experimentation we used eight adult rabbits. (Table III.) The ears were shaved and the central artery of one ear was cut across just proximal to its bifurcation near the tip of the ear. The blood was then allowed to drip into a measured amount of sodium oxalate solution until bleeding stopped spontaneously. The animal was then given an infusion of normal salt solution into the vein of the same ear as fast as it could be introduced through the largest needle the vein would accommodate. The quantity given was 50 cc. per Kg. of body weight, an amount which according to the estimation of Boycott<sup>18</sup> should be a little more than the total blood volume of the rabbit. The time required for injection was usually about ten minutes. The artery of the opposite ear was then cut across at the point corresponding to division of the artery of the first ear. The blood was again allowed to flow into oxalate solution until it ceased spontaneously. The amount was then compared with that lost from the first ear which was bled before injection. In all except two rabbits the amount of blood lost after

infusion was less than that lost before infusion. The extent of the hæmorrhage which occurred before infusion seemed to have no influence on the results obtained because diminished bleeding after infusion was shown both by those animals which bled most, and by those which bled least prior to infusion. The arteries of the two ears appeared to correspond very closely in size. When there seemed to be a difference, the smaller artery was severed before infusion.

The apparent reduction in bleeding and coagulation after saline infusions is not altogether illogical. According to Starling,<sup>23</sup> the behavior of colloidal solutions depends largely upon the conditions under which they exist in solution. At a particular hydrogen-ion concentration which differs for different proteins and which is called the iso-electric point, the protein is not charged and does not migrate in an electric field. When in solution on the acid side of their iso-electric points, protein particles carry a positive charge, whereas, on the alkaline side, their charge is negative. The charged condition of these particles is believed to play a considerable part in keeping them asunder and therefore preventing their aggregation and precipitation. Any agency which tends to discharge them will often cause precipitation and coagulation. Among such agencies the electric current and neutral salts are mentioned. Most colloidal solutions are unstable and the relations between their molecules and the surrounding fluid may be upset by slight changes of reaction or by the presence of minute traces of salts.

From the foregoing observations of Starling<sup>23</sup> it seems possible that coagulation of fibrinogen which exists in the blood-stream as a colloidal protein solution may be favored by the addition of sodium chloride which is a neutral salt. As a matter of fact, it appears that a number of crystalloid solutions promote the coagulation of blood. Neuhoof<sup>24</sup> recorded this effect following the introduction of sodium citrate into the blood-stream. This finding has had recent confirmation by Keiner and Holain.<sup>25</sup> Ravdin<sup>26</sup> and his associates found that glucose solution increases the power of coagulation in the blood of normal dogs and of jaundiced patients. Sodium chloride itself has been used by von den Velden<sup>27</sup> and Schenk<sup>28</sup> to increase the clotting power of the blood. Another possible factor in the apparent increase of coagulation following the infusion of normal saline is an increase of platelets, which in a few patients we have seen fairly consistently.

The solutions which have been most frequently used for intravenous infusion are physiological sodium chloride either simple or as Ringer's solution, glucose, and acacia. Sodium chloride and glucose are used in isotonic or hypertonic solution. When the purpose is to restore blood volume or tissue fluid we can see small logic in the use of hypertonic solutions. Their effect due to high osmotic pressure is to produce a temporary hydræmia at the expense of tissue fluids. This results in prompt loss of some of the solute and fluid through the kidneys. The remainder is distributed between the tissues and the blood-stream as normal osmotic relationships are restored, but the net result may be a loss rather than a gain of fluid. Hypertonic solutions are some-



## INFUSION TREATMENT OF SHOCK

times logically employed when the purpose is to restore a substance which has become depleted or to reduce an œdema of some part, notably the brain.<sup>29</sup>

Glucose is frequently given intravenously with the idea of providing water and at the same time nutrition. Its usefulness in combating acidosis is also taken into account. When an amount of glucose sufficient to be of any considerable nutritive value is given, unless it is injected very slowly the increased sugar content of the blood raises the osmotic pressure and diuresis associated with some loss of sugar is the result. It is generally believed, though not proved so far as we can determine, that the greater part of the glucose is utilized directly by the tissues or stored as glycogen. In Atchley's<sup>30</sup> opinion the nutritive effect of glucose so administered is negligible. It should be remembered that blood sugar in shock was usually found by Cannon and others to be normal or above normal and presumably it is sufficient to combat the accumulation of ketone bodies.

A solution of gum acacia in physiological saline has been advocated by Bayliss<sup>31</sup> for intravenous injection in shock. Its colloidal properties prevent its passage through the capillary walls and it constitutes a direct addition to the blood volume. Its osmotic properties, furthermore, tend to attract water from the tissues into the blood-stream. Most cases of secondary shock, however, are associated with dehydration and a large amount of normal sodium chloride solution which supplies fluid to the tissues as well as to the blood-stream would seem more logical.

In various ways normal salt solution offers advantages not possessed by the other agencies just mentioned. It has been shown by a number of observers<sup>32</sup> that water is best retained when administered with salts. Although their conceptions of its function differ, the importance of sodium chloride in the replacement of fluid lost from the upper gastro-intestinal tract has been stressed both by Haden and Orr<sup>33</sup> and by Gamble and Ross.<sup>34</sup> That sodium chloride may have a specific effect in maintaining proper dilution of the blood is indicated by recent work on adrenalectomized animals and on patients with Addison's disease. Swingle,<sup>35</sup> in his work on adrenalectomized dogs, found that fluid is continually lost from the circulation in animals deprived of the cortical hormone. When given abundant water they are unable to retain it and eventually die of circulatory collapse due to insufficiency of circulating fluid. The similarity of symptoms and signs to those of secondary shock is strikingly presented.

Marine and Baumann<sup>36</sup> and Rogoff<sup>37</sup> observed that the administration of sodium chloride solution prolonged the life of adrenalectomized animals and that it was beneficial as an adjunct to cortical extract in the treatment of Addison's disease. Loeb<sup>38</sup> and Harrop<sup>39</sup> have found that the sodium and chloride content of the blood plasma and of the extravascular tissue fluids are reduced in Addison's disease; the result is progressive dehydration and death with the symptoms of shock. Both observers have been able to restore the blood-pressure and bring about striking general improvement in patients by the use of large doses of salt alone, the cortical extract being omitted. It

would seem, therefore, that sodium chloride has an important specific effect in the maintenance and distribution of tissue and plasma fluids, and in supporting the normal level of blood-pressure.

In the foregoing discussion the similarity of findings in secondary shock and in dehydration and their probable close association in surgical practice has been presented. In the treatment of shock, therefore, the combination of water to overcome dehydration with salt which seems to have a part in the maintenance of normal blood-pressure appears logical. When there has been an important loss of blood, transfusion, of course, is indicated.

SUMMARY.—(1) Attention is again<sup>40</sup> called to the importance of dehydration as a factor in secondary shock.

(2) Physiological saline solution if given in large volume is efficacious in combating shock and shock-like conditions.

(3) The danger of overburdening the heart, of producing pulmonary oedema and of increasing hæmorrhage by the intravenous administration of large amounts of physiological saline has been exaggerated.

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## MYOSITIS OSSIFICANS (CIRCUMSCRIPTA) IN THE LIGAMENTUM NUCHÆ

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TO GUY PATIN<sup>1</sup> is attributed the first description of myositis ossificans, while writing in 1692, about a woman who had become as hard as wood all over. Freke,<sup>2</sup> in 1740, and Copping,<sup>3</sup> in 1741, reported similar cases of this condition. Bulhak,<sup>4</sup> in 1860, classified a progressive type and an isolated type occurring in exercise and riders' bones. This condition acquired its present name from Von Dusch,<sup>5</sup> in 1868. Munchmeyer<sup>6</sup> gave the first exact description of the disease in 1869, and collected twelve cases from the literature. In recent years many cases have appeared in the literature. In 1924, Magruder<sup>7</sup> collected 133 cases, including his own. Rosenstirn,<sup>8</sup> in 1918, made an extensive review of the literature, as did also Mackinnon,<sup>9</sup> Nutt,<sup>10</sup> and many others in more recent contributions. Noble,<sup>11</sup> in 1924, made a clinical and röntgenological study of this condition, and classified myositis ossificans into three types: First, progressive; second, myositis ossificans circumscripta; third, a localized (traumatic) type of myositis ossificans. The progressive type is confined to young individuals, one and then another muscle progressively becoming involved with relative increasing severity with respect to discomfort and restricted function. Barr believes that this condition apparently consists of a true metaplasia of connective tissue into bone. The second type (circumscripta) includes riders' bones and exercise bones, and has as an etiological factor repeated injury and irritation over a long period of time to a limited region. Third, the localized type is a true traumatic condition in which there has been tearing of muscle tissue, hæmorrhage, and perhaps injury to the periosteum and the muscle attachments thereto.

The cases herein reported fall in the second group, as neither gives a history of any direct injury; the condition manifesting itself at about middle age, having a probable etiological factor in the form of a collar-band or button irritation at the nape of the neck.

CASE 3434.—White, male, aged fifty, doctor of medicine. Present complaint is the sensation of a lump near the base of the back of his neck, which seems to come out, then disappear, and is not in itself painful except on pressure or manipulation, at which time it causes him to have a "sickish feeling," slight nausea, shortness of breath, and light-headedness. This lump was first noticed in May, 1933. It varies in prominence from day to day, but during the last three months it has become more noticeable, and he believes that it is decidedly increasing in size. Throwing his head backwards gives him this "sickish feeling." He notices this particularly when driving a car and going over bumps. The distress has become so eminent that the routine of making calls on his patients is looked upon with dread. A stiff tight collar aggravates the symptoms. He gives no history of injury. He had an attack of amœbic dysentery at twenty years of age with



JAMES E. M. THOMSON

six to ten stools daily for years. He ultimately recovered. He had gall-bladder disease beginning at about the age of twenty-one. He had a drainage and removal of the stones at the age of thirty-two with great relief for several years. The trouble recurred and the gall-bladder was removed in 1927. He has had some irregular digestive disturbances during the last few years with some pain in the right lower quadrant. He also had an appendectomy in 1912, and a tonsillectomy in 1926. The patient has lost twenty-five pounds in the last six months. He is subject to headaches and lumbago, but these have not been so bad recently. Both parents are living and over eighty years of age. His mother is a diabetic. There are three brothers and two sisters. One brother has diabetes. Physical examination briefly gives the following information. Blood-pressure is 122/76. Head: teeth were in good repair. No vestige of tonsils. Only slight redness in the post-pharyngeal region. Neck: a movable mass could be felt on deep pressure in the central posterior part of the neck about the level of the fifth or sixth cervical spine. The position of the mass varies with the movement of the head. It seems to have firm attachment. It can be moved more easily when the head is thrown back. It is especially tender on manipulation and deep palpation. There is nothing unusual in regard to the

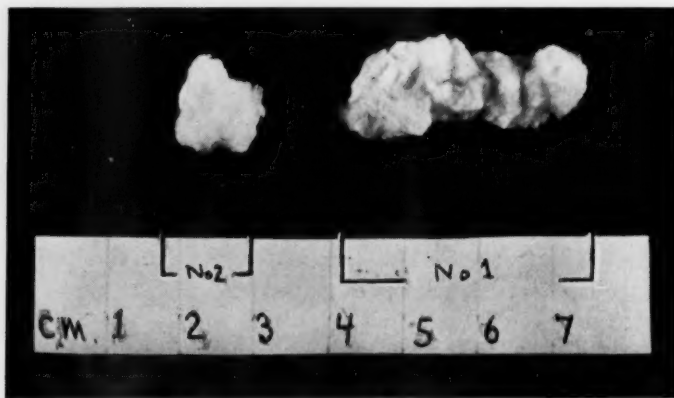


FIG. 1.—(CASE 3434.) Osteomata after removal from back of the neck. Actual size. The obliquity of the position of body No. 1, as it appears in the X-ray picture, accounts for difference in size and appearance of the removed specimen when compared with its appearance in the röntgenogram.

chest and abdomen, save for the scars as the result of previous operations and a slight tenderness in the right lower quadrant. Superficial and deep reflexes are normal.

Both anteroposterior stereoscopic and lateral röntgenograms were made of the cervical region. Stereoscopic röntgenograms show a body (Figs. 1 and 2) just to the right of the fifth cervical vertebra in the region of the spinous process. Another shadow a little lower down can be distinctly made out. Lateral röntgenograms show two bodies just behind the spinous processes of the fifth and sixth cervical vertebræ, the upper one larger than the lower. The upper appears to be elongated and extending backwards and upwards, while the lower, which is much smaller, seems rounded, with an extension of varying density upward and forward. These bodies appear of the consistency of bone, and are similar in density to the spinous processes of the cervical vertebræ, the larger body being three-eighths of an inch posterior to the fifth spinous process, the smaller one being one-eighth of an inch posterior to the sixth spinous process. Under local anæsthesia a longitudinal crescent-shaped incision was made over the area. These bodies were found to be deeply situated in the substance of the ligamentum nuchæ; the upper, larger body apparently penetrating the splenius capitis and the longissimus capitis muscles. They were firmly attached to the muscle fibres. The lower body, although close to the spinous process, was not attached to this process, but was loosely

## MYOSITIS OSSIFICANS IN LIGAMENTUM NUCHÆ

imbedded in the ligamentum nuchæ. The wound was closed and the neck placed in a cotton collar. No complicating circumstances arose during the convalescence. In the course of a couple of weeks the doctor was once more himself. He has been completely relieved of a very annoying, as well as disabling, condition.

The second case is that of O. F. W. (I am indebted to Dr. George H. Walker, of this city, for the clinical data connected with this case.) Aged fifty-five, white, male. The patient was a salesman. He had never been sick until about six months ago when



FIG. 2.—(CASE 3434.) Lateral röntgenogram of the cervical region, showing osteomata behind the fifth and sixth cervical vertebrae.

he began to run a temperature of varying degrees. Just ten days prior to his death he had a chill, developed a cough, and ultimately a left-sided pneumonia with pericarditis, myocarditis, and heart compensation. He died April 25, 1932. For several years he had complained of pain in the back of the neck, near its base. He had difficulty in moving the neck without painful discomfort in this region. The symptoms were aggravated by riding in a car or tipping the head backward. The post-mortem findings verified the clinical observations with respect to the thoracic pathology that caused his death. On account of the distressing neck complication, his family insisted on exploration of this region. A hard bony body was recovered from the substance ligamentum nuchæ behind

JAMES E. M. THOMSON

the seventh cervical vertebrae and extending upward three or four centimetres. No other pathological changes were found in this region.

These two cases occurring in males of about middle age, suffering the same symptoms, show a striking similarity. The one, recognizing the possibilities of surgical relief, is once more rehabilitated in his profession; the other, never seeking medical aid for the distressing neck symptoms, died of pneumonia. No other evidence of myositis ossificans was found in either of these patients. The fact that these osteomatous bodies occurred in the collar line of the neck, and the absence of a history of acute trauma, would lead one to the conclusion that possibly the continuous irritation of a tight or stiff collar band, or collar button, might be the etiological factor causing this condition. If my deduction is correct these two cases may be correctly classified as myositis ossificans circumscripta. A rather extensive search of the literature has not revealed any similar cases of muscular osteomata in the region of the ligamentum nuchae, except in young individuals severely afflicted with the progressive type of myositis ossificans.

Recalling the post-mortem findings of the second case (O. F. W.) a year later, gave me the clue to the diagnosis of the first case cited; and the gratifying results of the operative removal of these bodies would seem to justify this report. Perhaps these two cases are not sufficiently significant to warrant the suggestion that possibly Röntgen examination of patients suffering similar symptoms might reveal osteomata. Nevertheless, their coincidence, and the result obtained by operation, are interesting. The marked similarity between these bodies and those seen in hypertrophic (osteo-arthritic) arthritis cannot be overlooked, nor can it be entirely ruled out, as the calcareous deposits of both conditions are similar. However, the lack of X-ray evidence of arthritis in the case operated upon, and the lack of post-mortem evidence of hypertrophic arthritis in the case that died, rather indicates that these are osteomata of myositis ossificans circumscripta.

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## MYOSITIS OSSIFICANS IN LIGAMENTUM NUCHÆ

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## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

CATARACTS AND EXOPHTHALMOS\*

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THERE are two general groups of eye complications encountered in the surgical treatment of exophthalmic goitre. The first and least common complication is related to parathyroid insufficiency or parathyroid tetany caused by extirpation of the parathyroid glands during thyroidectomy. The second and much larger group is related to exophthalmos and the complications related to it. This report will be based on our experience at the Lahey Clinic in the treatment of 4,214 patients with exophthalmic goitre or primary hyperthyroidism. It is important to state in the beginning that these observations have been made and recorded by general surgeons and physicians not trained in ophthalmological methods of examination and diagnosis. However, we have had the valuable coöperation of ophthalmologists in seeing each of the patients who developed some eye complication, in addition to, or as a result of, either exophthalmos or parathyroid insufficiency. Since our routine examination of patients with exophthalmic goitre does not include a detailed examination of the eye, our discussion will be limited to our experience with the incidence and prevention of these complications, together with the results that we have observed post-operatively in these patients; the treatment of these complications will be referred to only briefly. Our clinical observations have been made at the time of the first examination of the patient, when their symptoms were most exaggerated, again during treatment and at the time of the follow-up examinations, carried out post-operatively every three months for the first year and annually after that time.

Exophthalmic goitre or primary hyperthyroidism for the purposes of this report can be considered a disease entity. There are sufficient clinical symptoms and signs, together with operative and pathological findings, to differentiate this group of cases from hyperthyroidism associated with other forms of goitre. In considering the eye complications of exophthalmic goitre it is important to strictly limit the cases coming under this diagnosis. For this reason we will state the important findings in this defined group of patients. They complain of nervousness, irritability, instability, fatigue, weakness of the skeletal musculature, increased sweating and sensation of warmth, loss of weight, decreased menstrual flow or amenorrhea, palpitation and other cardiac symptoms. They show activation, enlargement of the thyroid, tachycardia, forceful heart action, tremor of the extended fingers

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## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

and feet, a tremor which at times may be generalized, a moist smooth skin, exophthalmos and associated eye signs. The thyroid enlargement is symmetrical with a smooth outline, a firm consistency, with enlargement of the superior poles and frequently a bruit can be heard over the thyroid vessels. The basal metabolic rate is uniformly increased. The operative findings show a gland of uniform consistency with a fine lobulation and varying degrees of colloid deposit. The microscopical examination shows a fairly uniform hyperplasia, or varying degrees of involution. To be sure, it is unnecessary to have all of the findings just mentioned in order to establish the diagnosis of exophthalmic goitre. One or more of the "cardinal signs" may be absent and many of the secondary manifestations may not be evident. It is important to limit a discussion of eye complications to this group just described since exophthalmos is uncommon in any other form of goitre associated with hyperthyroidism. In a review of the literature dealing with eye complications in exophthalmic goitre this limitation has not been observed carefully so that there is a wide discrepancy in the reported incidence of eye complications.

*Cataracts Associated with Parathyroid Insufficiency.*—The occurrence of parathyroid tetany in our experience has been a rare finding. We have observed sixteen patients with parathyroid tetany following 5,883 operations for exophthalmic goitre, an incidence of 0.2 per cent. In addition, we have observed transient tetany in one patient with another form of goitre. In ten of these patients the symptoms of tetany were acute and transient. Six patients had persistent and chronic tetany of varying degrees of severity. One of these patients, a girl of twenty-one, died four and one-half months after subtotal thyroidectomy from parathyroid insufficiency. No eye complications developed before her death. Another young woman, twenty-two years of age, had moderate but persistent signs of tetany for three years which entirely disappeared following her first pregnancy. Her symptoms, while usually present, were not severe and on calcium therapy by mouth the blood-calcium level was maintained between 7.5 and 8.5 milligrams. No cataracts developed in this patient. A third patient, forty-one years of age, has had a moderately severe tetany for nearly two years and at present is developing small lens opacities. The fourth patient had very severe exophthalmic goitre and was operated upon in three stages. She developed tetany a few days after leaving the hospital after the final operation. Her blood calcium four months later was 5.5 milligrams. Unfortunately, she developed malignant and progressive exophthalmos which resulted in the loss of both eyes nine months after operation. Beginning changes were noted in the lens but no cataracts were evident. Cataracts developed in the other two patients, both of whom had severe tetany. The following case reports illustrate the development of cataracts as a result of parathyroid tetany.

CASE I.—Mrs. R. J. S., aged fifty-seven, came to the clinic in May, 1920, with a history of having had symptoms of exophthalmic goitre for two years. During the latter part of this time she had received several X-ray treatments. There was slight

prominence of her eyes at the first examination. Her metabolism test was plus 50. May 19, 1920, both superior thyroid arteries were ligated, leading to considerable improvement. July 14, 1920, subtotal thyroidectomy was done with relief of her symptoms. She was again seen in October, 1926, at which time she had recurrent hyperthyroidism with symptoms of six months' duration. Exophthalmos was present at this time. Her basal metabolic rate was plus 36. October 22, 1926, an excision of remnants from the left side was done, leaving little thyroid tissue on this side. No parathyroids were seen at either the primary or secondary operations nor on the resected specimens. Four days after operation she developed typical parathyroid tetany with a blood calcium in the neighborhood of 5.5 milligrams. She was given large amounts of calcium lactate daily as well as parathormone in doses of one to five cubic centimetres daily. In spite of all therapy the blood calcium could not be raised above 6.7 milligrams. April 29, 1927, a parathyroid was implanted in her neck from another patient. There was no demonstrable change in the condition of the tetany post-operatively. She returned home with persisting symptoms of tetany which were fairly well controlled with 250 grains of calcium lactate and with two to four cubic centimetres of parathormone daily.

Eighteen months after the onset of the symptoms of tetany her vision began to fail and two years later well-developed cataracts were evident. She was seen by Dr. J. H. Waite three years after operation, who found post-cortical cataracts in both eyes. These cataracts were removed by him without complication.

This patient was last examined in August, 1931, five years after the onset of her symptoms. No symptoms of tetany were present. The Chvostek and Trousseau signs were negative. The blood calcium was 7.5 milligrams. She was taking one dram of calcium chloride solution (50 per cent.) three times a day. In August, 1932, a report from her daughter stated that she was getting along well continuing the same therapy.

*Comment.*—The development of cataracts in this patient is very similar to the majority of reported cases. Subtotal thyroidectomy relieved the hyperthyroidism for six years but recurrence of symptoms made a secondary resection of thyroid remnants necessary. Parathyroid insufficiency followed the secondary operation. Parathyroid transplantation was carried out without demonstrable benefit. We have previously reported<sup>1</sup> our experience with homotransplantation in three patients, none of whom was helped. A review of the cases reported in the literature failed to disclose a single instance of permanent benefit from homotransplantation of a parathyroid gland. Several isolated reports claimed to have relieved tetany by this means but each seemed open to question. The visual disturbances in this patient were slow in developing, being noticed after eighteen months. Three years elapsed before the cataracts were mature.

CASE II.—Mrs. A. K., aged fifty-five, was first examined September 19, 1923. She had been suffering with severe exophthalmic goitre for three years and at the time of the first examination had congestive heart failure. She was prepared for operation by medical treatment for the decompensation. When the heart failure was relieved her metabolism test was plus 48. She was operated upon in three stages; first, bilateral superior pole ligations, October 23, 1923; followed by hemithyroidectomies carried out November 16, and December 15, 1923. No symptoms of parathyroid tetany were noticed during the seven-day period that she remained in the hospital after the last operation. Soon after returning home, however, her family physician noticed the characteristic signs and symptoms of parathyroid tetany. She would not return for study, however, until twelve months after the onset of her symptoms, at which time they were so severe

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

that she was incapacitated. Her metabolism test at this time was normal. The calcium was withheld for four days, following which her blood calcium was 3.9 milligrams. After taking large doses of calcium by mouth the blood calcium varied from 5.2 milligrams to 5.8 milligrams. On this therapy she became relatively free of spasm. She was placed on parathyroid extract without being able to change the level of the blood calcium in spite of five cubic-centimetre doses.

She was seen by Dr. F. M. Spaulding twelve months after the onset of her tetany, who reported that there was beginning cataract formation in both eyes. For the next year her symptoms were relatively well controlled by calcium therapy by mouth. Two and one-half years after the onset of the symptoms she was free of tetany, taking ninety grains of calcium lactate daily. An increase in the dosage resulted in abdominal distress and diarrhoea while a decrease immediately resulted in the return of the spasms. At this time a bilateral cataract extraction was performed by Doctor Spaulding. Two years later, or approximately five years after the onset of her symptoms, the tetany was still latent but fairly well controlled with continuation of the same therapy. She was again having a failing in vision in spite of the previous cataract operation.

This patient differs from the first case in that she did not have a secondary thyroidectomy. She presented an even more severe form of tetany as evidenced by the persisting lower blood calcium. She was not benefited by parathormone, in spite of the use of large doses. Beginning cataracts were noticed in one year and were well marked in two and one-half years.

It is beyond the scope of this paper to discuss the eye findings in these patients with parathyroid tetany. O'Brien<sup>2</sup> gave an excellent review of the literature in 1932, and this paper and bibliography can be referred to. He was able to collect forty-two cases of cataracts from this cause, the first being reported by Landsberg in 1888. O'Brien reported three additional patients in whom he had done extractions. He found that cataracts did not develop in all cases of tetany although he was of the opinion that some of these patients may have been treated for cataracts without the knowledge of the authors reporting the tetany cases. Cataracts developed in some patients with latent tetany in whom the clinical symptoms were not conspicuous. He concluded that "rapidly developing bilateral cataracts in presenile persons, especially those of the female sex, may be due to post-operative tetany." In the reported cases cataracts have been noted as early as six months after operation. Our two patients first noticed disturbances of vision in twelve and eighteen months and were mature in two and one-half and three years. This time interval is characteristic of the majority of the reported cases. The mechanism in the formation of cataracts is not settled. The earlier theories, that the spasms were responsible or that a toxin caused them, seem untenable. The alteration in the metabolism of calcium and phosphorus probably accounts for their formation. While the calcium content of the lens is not greater than in cataracts of other cause, the increase in the blood phosphorus suggests this as the important factor.

Dr. William P. Beetham<sup>3</sup> has been able to find twenty additional cases since O'Brien's report. The total number of sixty-seven cases, including those reported in this paper, probably does not represent the true incidence of this complication, since it is certain that some have been unrecognized as

of this cause and in addition there must have been a considerable number not reported.

It seems inevitable that cataracts will develop in severe and chronic tetany, and occasionally in latent tetany, in spite of as adequate therapy as possible directed to the parathyroid insufficiency. In the more frequent acute and transient forms of tetany no eye complications have been observed. The avoidance of this eye complication is primarily a preventive and a surgical problem; that is, it is necessary to make certain that the parathyroids are not removed at operation. Since 1925 we have carefully examined each resected gland at the time of operation for parathyroids that have been inadvertently removed. These are immediately implanted in the sternomastoid muscle. This may have been a factor in reducing the incidence of tetany, since we have been able to show experimentally in dogs that such an implanted gland can carry on the normal parathyroid function when a deficiency has been created. Post-operatively, there is no prospect that a transplantation from another patient will be of any benefit. We have modified our operative technic so as to give the maximum of protection to the parathyroids and have been able to markedly reduce the incidence of tetany. It is more difficult to prevent removal of the parathyroids in secondary operations for recurrent or persistent hyperthyroidism. O'Brien found that many of the reported cases had secondary operations on the thyroid and believed this to be a definite factor in the incidence of tetany. We have done secondary operations for recurrent or persistent hyperthyroidism in 352 patients and in this group three patients developed tetany. One of these developed cataracts (Case I), while in the other two the symptoms were of brief duration and no eye complications resulted. In the last 6,000 goitre operations, tetany has occurred but four times and in only one of these patients have the symptoms been persistent. If tetany persists and becomes chronic, even though the symptoms are controlled by calcium therapy, these patients should be under the care of an ophthalmologist. When cataracts have developed their operative removal at the proper time will usually be indicated.

*Exophthalmos.*—Exophthalmos has always been considered one of the cardinal signs in exophthalmic goitre or primary hyperthyroidism. It was first mentioned in connection with goitre by Parry in his early description of this condition. While it is present in only one-half of the patients suffering with this condition it has always been of considerable aid in establishing the diagnosis, since it has called attention to a possible thyroid condition even in the absence of obvious thyroid enlargement. A large number of associated eye signs have been described to which men's names have been attached. Most of these are dependent on the degree of exophthalmos present or due to the same factors as produce it. For several years we were very zealous in observing and recording the incidence of these various secondary eye signs but they proved of little importance as an aid in establishing the diagnosis of this condition and we no longer record their presence. The

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

following table describes a number of these signs, which are frequently observed in exophthalmic goitre.

Dalrymple	Retraction of the upper lid producing wide palpebral fissures (stare).
von Graefe	Lid lag (tardy downward movement of the lids when rotating the eyeballs downward).
Stellwag	Imperfect lid closure with winking (diminished winking frequency).
Moebius	Imperfect convergence.
Gifford	Difficulty in eversion of the upper eyelid.
Kocher	Movement of the lid upward with the eyeball following more slowly when looking upward.
Sukers	Visual fixation from extreme lateral rotation of the globe.
Rosenbach	Fibrillary tremor of the closed eyelids.
Wilder	Jerking and twitching of the globe when moving the eyes from extreme abduction to adduction.
Joffroy	Absence of brow wrinkling when looking upward with the head down.
Jellinek	Pigmentation and œdema of the lids.

We have occasionally observed paresis of one or more of the extra-ocular muscles. This finding has been reported by Williard,<sup>4</sup> and Heuer.<sup>5</sup> Chemosis, conjunctivitis, associated with extreme exophthalmos are very common. Corneal ulceration is more rare. (Fig. 5A.) At times there is a nystagmic tremor or movement of the globes, and in a few instances orbital bruits have been described. One of our patients showed optic atrophy similar to the patient reported by Keogh.<sup>6</sup> Pulsation of the retinal vessels is a more common and characteristic finding. One of our patients had dislocation of the eyeballs on her cheek with sudden ocular movements.

While these various signs and eye complications are of great interest we have found only two of them to be of any appreciable value in establishing the diagnosis of exophthalmic goitre. These are exophthalmos and stare. (Figs. 1, 2, 3 and 4.) We have determined the presence or absence of exophthalmos first by questioning the patient or the patient's family in regard to a change in the prominence of the eyes and second by observation of the eyes from a front and lateral view at the time of ocular movements. We feel that this is the only reasonably accurate way of determining whether exophthalmos is present. Recently we have been using the Hertel exophthalmometer as a means of measuring the actual proptosis in order to have a means of comparing it with the relative position of the eyes after relief of the hyperthyroidism. While exophthalmos is present in only one-half of the patients, stare is a very constant finding. We have found some degree of fixation or stare in over 90 per cent. of our patients. These eye signs, however, are of less help in the border-line case or incipient hyperthyroidism.

There are, of course, many other causes for exophthalmos exclusive of hyperthyroidism. It is observed in sinus disease, in aneurism and arteriovenous communication of the cervical and intracranial vessels, accompanying



intra-orbital and intracranial tumors, with thrombosis of the ophthalmic vein and cavernous sinus. It is observed in Christian's syndrome, in rare cases of encephalitis and meningitis and in certain patients with nephritis and cardiac disease. It is observed at times following the administration of thyroid extract and rarely can be produced voluntarily.<sup>30, 31</sup>

The cause or causes and means of production of exophthalmos in exophthalmic goitre are still unsettled. These have recently been reviewed by Naffziger,<sup>7</sup> Burch,<sup>27</sup> and Merrill and Oaks.<sup>28</sup> One of the first mentioned was an increase in the intra-orbital fat pushing the globe forward. This can be discarded as a negligible factor based on the post-mortem findings in the orbit in a large number of cases, and because operative removal of fat has not decreased the exophthalmos. Marine, Rosen and Cipra<sup>8</sup> have produced



FIG. 1.

FIG. 2.

FIG. 1.—The characteristic eye-signs are very noticeable in this girl of nine years with exophthalmic goitre. The palpebral fissures are widened. There is a fixed, staring expression and the eyes are very prominent.

FIG. 2.—Exophthalmos and stare in a woman of fifty-eight years with exophthalmic goitre. There is also swelling of both upper and lower lids.

chronic, progressive, bilateral exophthalmos in rabbits by daily injections of methyl cyanide. Thyroidectomy made the degree of exophthalmos greater. It seems difficult, however, to attribute exophthalmos to any chemical or toxic cause in patients with exophthalmic goitre. Retrobulbar venous engorgement is capable of producing exophthalmos as shown experimentally by MacCallum and Cornell.<sup>9</sup> Ligation or thrombosis of the retrobulbar veins has been shown to produce it. A recent clinical observation of ours indicates the part venous obstruction may play. This patient had bilateral exophthalmos remaining after removal of benign intra-orbital tumors some years previously. She developed stridor due to tracheal obstruction of unknown cause. With each

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

spasm of respiratory difficulty the cervical veins became engorged and the exophthalmos was considerably increased. The increase in the prominence of the eyes seemed definitely related to the venous engorgement. Tilley<sup>10</sup> suggested that there was a mechanical balance between the restraint of the lid on the globe and the action of Muller's muscle in forcing the globe forward. When the lid retracts a mechanical protrusion results, according to his belief. The influence of the cervical sympathetic has been shown repeatedly. Galvanic stimulation of the cervical sympathetic trunk<sup>9</sup> and the isolated experiments of Cannon<sup>11</sup> in getting repeated stimulation from nerve anastomosis have produced exophthalmos. Horrax<sup>12</sup> repeated Cannon's experiments and observed exophthalmos in some of his animals. Similar experiments by others failed to produce exophthalmos. In the normal individual resection of the superior cervical ganglion, of course, results in the typical Horner syndrome of enophthalmos, contracted pupil and ptosis of the lid. Unfortunately, this operation, carried out with exophthalmos present, has not given uniformly good results in the treatment of exophthalmos although carried out by a number of surgeons.<sup>13, 14, 15</sup> Naffziger<sup>16</sup> has recently again called attention to hypertrophic changes in the extra-ocular muscles accompanied by marked oedema and lymphocytic infiltration. These findings have been recorded in isolated cases for a great many years and probably constitute a very important cause of exophthalmos, particularly that which is permanent and progressive.

From a review of the literature and from our clinical experience, it seems that the proptosis seen in patients with exophthalmic goitre is due to more than one cause. The facial appearance of these patients, simulating the state of fright, suggests a sympathetic influence. The rapidity with which the exophthalmos frequently disappears after the relief of the hyperthyroidism indicates a nervous origin rather than an anatomical change within the orbit. Improvement in the exophthalmos by excision of the superior cervical ganglion is strong evidence of this factor, while sympathetic stimulation will explain many cases, there is a group of patients with long-standing exophthalmos in which another explanation must be found. These are adequately explained by Naffziger's<sup>7, 16</sup> findings. At present we must accept these two causes as the most likely ones to explain the exophthalmos in our case.

In order to find the incidence of exophthalmos and the expectation of relief after thyroidectomy we have taken the records of 800 patients with exophthalmic goitre who were observed and operated upon during 1928 and 1929. During this two-year period 984 patients with exophthalmic goitre were treated. No selection of the histories has been made but 800 consecutive records were studied. It will be noted from Table I that not quite one-half of patients with exophthalmic goitre show this cardinal symptom, which gives the disease its name.

RICHARD B. CATTELL

TABLE I

Exophthalmos .....	364	46%
No exophthalmos .....	421	52%
Not stated .....	15	2%
<hr/>		<hr/>
Total patients .....	800	100%

One hundred six of our patients gave exophthalmos as a presenting symptom or chief complaint, or at least noticed it at the same time as the onset of the other symptoms. However, on closely questioning many of them, symptoms definitely related to hyperthyroidism could be elicited as occurring some time previously. In the entire series one in eight patients gave exophthalmos as a presenting symptom, while one in four, of the ones who had exophthalmos, gave it as a presenting symptom. Claiborne<sup>17</sup> felt that exophthalmos was the first or presenting sign of exophthalmic goitre. This has been denied by Bulson, Wilder and Jackson<sup>18</sup> and Bram,<sup>19</sup> who felt that it developed more slowly.

Nine patients in this group of 364 had unilateral exophthalmos; (Fig. 7) it occurred in the left eye five times and four in the right. In this group four had disappearance of the exophthalmos, two had persistence of it associated with toxic symptoms while three could not be followed. Thirteen patients had asymmetrical exophthalmos, being conspicuously more evident in one eye. These findings seem to be of little practical importance, except in the patients with doubtful toxicity, where the differential diagnosis is more difficult. In the patients who have had unilateral exophthalmos and were border-line cases of hyperthyroidism, thyroidectomy has given disappointing results.

We were unable to show any relation between the severity of the disease and the degree of exophthalmos. There was, however, an important relation between severity of the proptosis and the duration of the disease. It is, of course, obvious that the neglected cases and those that had had the disease for a number of years have a higher incidence of exophthalmos as well as a greater prominence. (Fig. 4.)

We have seen exophthalmos on occasion in other forms of goitre without an extrathyroid cause for it. We believe, however, that hyperthyroidism is essentially the same process whether it is in its primary form (exophthalmic goitre), or associated with other forms of goitre which readily explains the findings in secondary hyperthyroidism. Exophthalmos has been described in non-toxic goitre relieved by thyroidectomy<sup>20</sup> but we must assume in these cases that mild degrees of hyperthyroidism were present or that some extrathyroid cause exists.

Exophthalmos is more common in women than men, as shown in Table II.

We have observed exophthalmos in all ages from two years and eleven months to seventy-six years of age. The age incidence in the cases studied seems to be of little importance as shown in Table III. In comparison with the age incidence of exophthalmic goitre it shows little variation.

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

TABLE II

*Sex incidence of exophthalmos (800 pts.)*

Male .....	80	10%
Female .....	720	90%
Ratio with exophthalmos.....	1:10	
Ratio with exophthalmic goitre (men: women).....	1:6	
Exophthalmos more common in women.		

TABLE III

*Age incidence of exophthalmos (390 pts.)*

6 years .....	1
11-20 years .....	25
21-30 years .....	99
31-40 years .....	118
41-50 years .....	93
51-60 years .....	44
61-70 years .....	10

Exophthalmos comes during the decades where exophthalmic goitre is most frequent; the largest number being observed from thirty-one to forty years of age, being about equal in the third and fifth decades.

Since the presence of exophthalmos can be considered as a later development of exophthalmic goitre the prevention of severe grade of exophthalmos and secondary complications due to it resolves itself into the early relief of the hyperthyroidism. In the past, when the operative mortality was so high as to be deterrent to operation, neglect of treatment resulted in serious eye complications and occasionally in loss of the eyes. At the present time with the operative mortality reduced well below 1 per cent. subtotal thyroidectomy will prevent the development of exophthalmos in nearly all patients. The early diagnosis and treatment of exophthalmic goitre is the crux of the situation. During the last two or three years we have seen more and more cases during the first three months of the disease and in this group the incidence of exophthalmos is definitely lower. When it is present, it is important to adequately protect the cornea both before, during and immediately after operation. Patients with unusually prominent eyes or with chemosis, conjunctivitis or early ulceration of the cornea are placed under the care of an ophthalmologist for preventive treatment. During operation all patients with prominent eyes have a lubricant put in the eyes to prevent scratching of the cornea during anaesthesia. In addition pledgetts of cotton are used to keep the upper lids closed for further protection as well as to prevent leakage of the anaesthetic agent. We have tried, on occasion, to use shields and other devices for the protection of the very prominent eyes but have not found anything that is satisfactory. In ten or twelve patients with extreme exophthalmos, we have found it necessary to have the lids sutured together at the beginning of the operation in order to offer sufficient protection to the eyes. (Fig. 6A.) These sutures have been left for a few days after opera-

tion. After operation it is equally important to carry out precautionary measures as well as active treatment as indicated by the condition of the eyes.

What prognosis or prospect of relief of the exophthalmos can we give patients who have it associated with exophthalmic goitre? In order to answer this question as accurately as possible we have studied the follow-up records of the 364 patients who had exophthalmos in this series of 800. The routine follow-up examination of these patients includes a general physical examination, a notation as to the condition of the eyes as well as a basal metabolism test. As stated earlier in the paper these patients return every three months for a year for this examination as well as annually for a five-year period. A tabulation of these results is seen in Table IV.



FIG. 3.

FIG. 3A.

FIG. 3.—Very severe exophthalmic goitre in a boy of eighteen with marked emaciation. Exophthalmos, stare and edema of the lids were present.

FIG. 3A.—The same patient as in Fig. 3 three months after the completion of a two-stage thyroidectomy. This photograph illustrates the rapid disappearance of the eye signs that occurs in the majority of patients.

TABLE IV

*The relief of exophthalmos (364 pts.)*

Complete disappearance of exophthalmos..	183	50.3%
Improvement .....	48	13.2%
Persistent or recurrent.....	79	21.7%
Increase .....	4	1.1%
Not followed .....	50	13.7%
Total patients with exophthalmos.....	364	100 %

It will be noted from Table IV that one-half of the patients who had exophthalmos before operation had complete disappearance of it. (Figs. 3 and 3A.) An additional 13 per cent. had improvement but still had some



## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

remaining prominence of the eyes, that is, 63.5 per cent. of patients had an improvement in their exophthalmos as a result of subtotal thyroidectomy. If one considers the incidence of relief in the patients who were observed (314), 58.3 per cent. were entirely relieved while 15.3 per cent. were improved; a total of improvement of 73.6 per cent. These findings are in agreement with an earlier report from the clinic by Doctors Clute and Veal.<sup>21</sup> Bram<sup>19</sup> states that the exophthalmos will disappear in all cases after a long time, but this has not been our experience.

A further consideration of the group of 183 patients in whom the exophthalmos completely disappeared brings out clearly the time necessary to effect this change. These results are presented in Table V.

TABLE V  
*Patients relieved of exophthalmos 183*

Time of Disappearance		
(A) Patients observed every 3 months—149		
Relieved in 3 months.....	109	73.2%
Present 3 months, relieved 6 months.....	16	10.8%
Present 3 and 6 months, relieved 9 months....	9	6.0%
Present 3, 6, and 9 months, relieved 1 year...	15	10. %
Total patients .....	149	100%
(B) Time of disappearance when first seen—34		
Relieved 4-6 months .....	11	
Relieved 7-9 months .....	5	
Relieved 1+ year .....	14	
Not stated .....	4	

It will be noted in Table V that 149 patients returned three months after operation, and of this group 73 per cent. had complete relief in this short period of time. (Figs. 3 and 3A.) In forty of these patients some degree of exophthalmos was still present at the end of three months but was entirely absent during subsequent examinations at six, nine and twelve months after operation. In the second portion of Table V it will be seen that thirty-four patients did not return three months after operation, but did come back for examination some time during a twelve-months period post-operatively. This small group of patients was considered separately since it would confuse the results presented in the first portion of the table.

During the past few months we have had the opportunity of observing patients repeatedly during the first three months after operation. We have been able to check the degree of exophthalmos present by means of the exophthalmometer. Small decreases in the exophthalmos have been noted during the short pre-operative period that the patients have been observed in the hospital—an interval of seven to twelve days. This regression is by no means constant. For a number of years we have noted the fact that four to six days after subtotal thyroidectomy a rather striking decrease in the exophthalmos and fixation or stare has been noted in certain cases. The

RICHARD B. CATTELL

improvement during the first few weeks after operation is steady and progressive in the majority of patients.

In forty-eight patients, or 13.2 per cent. of the total number with exophthalmos, improvement was noted but some prominence remained. This group is considered in Table VI.

TABLE VI

(A) Duration of exophthalmos		
Under one year .....	18	18
1-2 years .....	10	
3-4 years .....	4	
5 years + .....	7	21
Not stated .....		9
<i>Patients with exophthalmos improved 48</i>		
(B) Factors influencing exophthalmos		
Still toxic .....	8	
Duration over 1 year.....	16	
(not toxic)		
Undetermined (Relief P. H.) .....	15	
Not stated .....	9	
Nearly one-half with exophthalmos after operation had been present over 1 year.		
One in five had persistence of toxicity.		

It will be noted from these figures that over half of the ones in which the duration of the exophthalmos was known it had been noticed longer than one year. In order to find some reason for the persistence of some degree of exophthalmos this group was studied from the standpoint of their metabolism test as well as duration. Eight of the group still had clinical toxicity with elevated basal metabolic rates. Sixteen had been present over a year pre-operatively although all of this number had normal metabolism tests. (Figs. 4 and 4A.)

*Persistence or Recurrence of Exophthalmos.*—In the total group of patients with exophthalmos (364), seventy-nine, or 21.7 per cent., had a persistence of their exophthalmos, of essentially the same degree or had improvement or disappearance followed by recurrence of the exophthalmos. An analysis of this group is presented in Table VII.

TABLE VII

*Persistence or recurrence of exophthalmos 79*

Exophthalmos under 1 year .....	33
Exophthalmos 1-5 years .....	20
Exophthalmos 5-21 years .....	8
(5, 6, 7, 8½, 9, 10, 13, 21 years)	
Not stated .....	18
<hr/>	
Still toxic .....	24
Myxœdema .....	8

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

It will be noted that twenty-eight of the group had had exophthalmos from one to twenty-one years. A large proportion of the patients having had exophthalmos of under one year's duration had either a persistence or recurrence of their hyperthyroidism. A smaller number (eight) had definite post-operative hypothyroidism or myxœdema. (Fig. 5.) Gasteiger<sup>22</sup> reported a case of this type.

A consideration of the group in whom the exophthalmos was improved or persistent points out three general groups of patients in whom we have little prospect of having disappearance of the exophthalmos after the surgical treatment of their hyperthyroidism. Those patients who have had exophthal-



FIG. 4.

FIG. 4A.

FIG. 4.—Marked exophthalmos of three years' duration associated with epiphora and conjunctivitis. The thyroid enlargement is noticeable.

FIG. 4A.—A photograph of the patient shown in Fig. 4 a week following a second-stage lobectomy. The exophthalmos is less evident although a considerable degree remains. This patient's eyes have not changed during a later two-year observation period and her eyes will undoubtedly always remain prominent because of the duration previous to operation.

mos for a considerable period of time, many of whom will have the more severe degree of the condition, have little prospect that their eyes will regain a normal appearance. Patients in whom there is a persistence or recurrence of the hyperthyroidism will still have an unsatisfactory result with their eyes. In a small group with myxœdema the appearance of the eyes will be unsatisfactory either from prominence or from puffiness of the lids. (Fig. 5.) Doctor Lahey<sup>32</sup> and Doctor Clute,<sup>23</sup> in reporting the surgical results of hyperthyroidism, have shown that recurrence or persistence of toxicity will result in 2 to 6 per cent. of the patients in the different series studied. In this small group the eye signs will persist.

In a small group (twenty-six) of patients in whom exophthalmos was not present before operation it developed post-operatively. In ten there was a persistence or recurrence of toxicity which readily explained this finding. In twelve patients some degree of exophthalmos was evident although their metabolism test was normal and there were no other clinical signs of hyperthyroidism. Four patients had myxoedema with prominence of their eyes associated with cedema of the lids. The eye condition was improved by the administration of thyroid extract. It is quite possible that the observation

was incorrect in some of the group of sixteen patients without evidence of toxicity after operation.

*Progressive Exophthalmos.*—

It has long been recognized that patients with exophthalmic goitre may lose both eyes. Von Graefe<sup>24</sup> reported three patients who lost both eyes and was able to collect twenty from the literature up to 1857. In numerous reports since that time many other such instances have been reported. With adequate surgical therapy, however, this is a very unusual finding. Earlier in the experience of the clinic, three patients lost both eyes because of progressive exophthalmos. The report of one of these patients follows:



FIG. 5.—Residual exophthalmos and puffiness of the eyes one year after subtotal thyroidectomy. The basal metabolic rate was minus 20. Improvement was noted after the administration of thyroid extract. The appearance of the eyes may be unsatisfactory when associated with post-operative myxoedema.

prominent during this time. She entered the hospital in November, 1924, at which time her basal metabolic rate was plus 109, and her resting pulse rate 124. She was operated upon in three stages, the last being performed in January, 1925. After leaving the hospital, she developed parathyroid tetany and was treated by her family physician. The exophthalmos increased after operation and she was seen by Dr. Louisa P. Tingley three weeks later, who reported that "the exophthalmos was so pronounced that it was impossible for the patient to rotate her eyes from side to side or to close her eyelids voluntarily. Manual closure of the eyelids was possible. There was a marked conjunctivitis and a constant epiphora. The eyelids were discolored and the pupils moderately dilated. The fundi showed arterial pulsation." In May, 1925, the eyes were in such bad condition that their loss seemed certain. At this time her metabolism test was normal. She had symptoms of parathyroid tetany and her blood calcium was 5.5 milligrams. She refused

CASE III.—Mrs. M. S. O'D., aged thirty-six, was first seen in August, 1924, with exophthalmic goitre of one year's duration. Her eyes had been

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

operation at this time. In September, 1925, vision was gone although there was light perception in the left eye. The corneas of both eyes were sloughing and the lens of the right eye had delivered itself with collapse of the interior chamber. (Fig. 5A.) The ocular muscles were so relaxed that the right eye was resting on her cheek. The globe could not be replaced in the orbit due to the extreme amount of oedema. The lids were oedematous and could not be closed. On September 18, 1925, nine months after operation, Doctor Tingley enucleated both eyes, closing the conjunctivæ with purse-string sutures.

This case presents the findings that are typical of the reported cases in whom both eyes have been lost. Wurdemann<sup>25</sup> reported one patient with similar findings in 1906. Two similar cases have been recently (1933) reported by Merrill and Oaks.<sup>28</sup>

Recently Zimmerman<sup>26</sup> and others have called attention to the development of progressive exophthalmos after the surgical relief of the hyperthyroidism. In the group of patients considered in this discussion only four had an increase in their exophthalmos after operation. Two of these patients still remained toxic while the other two were relieved of their hyperthyroidism. Since 1929, we have seen an occasional patient with progressive exophthalmos (Figs. 6, 6A and 6B), none of whom has lost his eyes. This complication is well illustrated by the following case report:



FIG. 5A.—Malignant and progressive exophthalmos leading to the loss of both eyes. Marked oedema and panophthalmitis were present. Bilateral enucleation became necessary. (Case III.)

CASE IV.—Mrs. G. H. A., aged twenty-eight, came to the clinic on August 4, 1930, because of prominence of her left eye and double vision. The patient noticed double vision in June, 1930, and, consulting a physician, was told that her left eye was prominent. He also found some enlargement of the thyroid. She took iodine which improved her symptoms, but the eye remained the same. She was seen by Doctor Horrax who could find no intracranial or orbital cause for the exophthalmos. When seen by us, this patient had exophthalmic goitre with marked unilateral exophthalmos. (Fig. 7.) Her metabolism test was plus 32. A subtotal thyroidectomy was done on August 18, 1930. She developed severe conjunctivitis and ulceration of the left cornea following operation. It was noted that the patient was unable to close her eye



RICHARD B. CATTELL

and it remained open when she slept. Doctor Waite saw her in consultation and found an abrasion of the left cornea. She was very uncoöperative so that it became necessary to suture her lids on the second day after operation.



FIG. 6.

FIG. 6A.

FIG. 6.—Malignant and progressive exophthalmos present eighteen months after subtotal thyroidectomy done elsewhere. A secondary operation for persistent hyperthyroidism was done one month after this photograph was taken. The eye condition has not been improved although the metabolism test is now normal.

FIG. 6A.—A lateral view of the same patient shown in Fig. 6, showing the extreme exophthalmos.

She was seen on November 21, 1930, at which time her metabolism test was normal and there was no further evidence of toxicity. Her eyes were in very bad condition at that time and both were prominent. The lids did not meet on either side for more



FIG. 6B.—Photograph of the patient shown in Fig. 6 taken two days after the secondary operation. The eyes are now completely covered and protected by the suture of the lids done just before thyroidectomy.

than an eighth of an inch, and she was developing progressive exophthalmos in the right eye. At this time an external canthoplasty and lid suture were done. She was

## EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

seen again January 12, 1931, at which time her right eye was somewhat improved. The lid sutures had pulled out somewhat from the left eye, but the cornea was still pretty well covered. May 7, 1931, she had a very tremendous bilateral exophthalmos, measuring thirty millimetres in each eye. Both eyes were now the same. May 25, 1931, Doctor Waite had resected the outer wall of the orbit on one side, allowing the eye to recede from thirty-four millimetres to twenty-four millimetres. At the same time, division of the upper lid, through the tarso-orbital septum, and lid sutures were carried out. The outlook in this case is unfavorable. The Naffziger operation should be considered but the patient refuses further treatment.

In the treatment of extreme exophthalmos a number of operative procedures have been carried out on our patients. Cervical sympathectomy has failed to materially influence the exophthalmos but it must be stated that this operation was employed in progressive exophthalmos and it does not seem reasonable to expect relief in this group. Plastic operations on the external canthus in order to decrease the palpebral fissure have been of little benefit. In the acute cases scarification of the lid margin with suture of the eyelids together has been of aid in the prevention of injuries to the cornea. (Fig. 6B.) The reported case is the only patient with progressive exophthalmos in whom a radical operation has been performed and in this patient the lateral wall of the orbit was resected in order to decompress the orbit.\* Naffziger<sup>16</sup> has advocated and used an intracranial operation in which the roof of the orbit is removed as well as the upper



FIG. 7.—Unilateral exophthalmos due to exophthalmic goitre. This condition later became a malignant and progressive exophthalmos involving both eyes. (Case IV.)

margin of the optic foramen. These operations are based on the post-mortem findings in extreme exophthalmos of intra-orbital oedema and increase in bulk of the extra-ocular muscle. Since this report we have not had a patient with progressive exophthalmos in whom the operation seemed indicated.\*

**Conclusions.**—Two types of eye complications are seen associated with the operative treatment of exophthalmic goitre—(1) cataracts associated with parathyroid tetany, and (2) exophthalmos, with its associated signs.

\* Since this paper was written Dr. Gilbert Horrax has done the Naffziger operation three times on two of our patients.

Parathyroid tetany occurred sixteen times in 4,214 patients with exophthalmic goitre after thyroidectomy and in two cataracts developed.

Exophthalmos occurs in approximately one-half of patients with exophthalmic goitre or primary hyperthyroidism. It is a presenting symptom in one of each eight patients. Its development is slow and usually follows other symptoms.

The degree of exophthalmos does not parallel the severity of the disease but is related to the duration of symptoms. It is rarely unilateral, but may be asymmetrical.

In the series of 364 patients with exophthalmos approximately 50 per cent. were relieved of their exophthalmos while an additional 13 per cent. were improved.

In 73 per cent. of the patients in whom the exophthalmos disappeared post-operatively this change was effected within the first three months after thyroidectomy. If the exophthalmos has been present for a considerable period of time the chance of relief is markedly diminished. A recurrence or persistence of the hyperthyroidism is frequently accompanied by exophthalmos.

Serious degrees of exophthalmos are rarely encountered and progressive exophthalmos is an unusual finding. In these patients in whom the hyperthyroidism has been relieved and the exophthalmos becomes more severe some method of decompression of the orbital tissues may be necessary.

With the early diagnosis and treatment of hyperthyroidism, with careful protection of the eyes during operation and with adequate protection of the parathyroids, few serious eye complications will be encountered in the surgical treatment of exophthalmic goitre.

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# EYE COMPLICATIONS IN EXOPHTHALMIC GOITRE

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## TRAUMATIC SUBDURAL HÆMORRHAGE

SURGICAL REMOVAL OF CLOT; RECOVERY

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The interest in subdural hæmorrhage is not only its rarity in being clinically recognized and subsequently operated upon with recovery as there are only a few reported cases in the literature, but its rather obscure etiology in cases of head injury caused by a seemingly insignificant blow. It is almost inconceivable that a slight injury without fracturing the skull could cause hæmorrhage under the dura and the mechanism by which it is produced is not so easily understood. Undoubtedly some other factors inherent in the tissues predispose to this type of lesion which, according to Freeman,<sup>1</sup> may even occur in the absence of trauma. Since the time of Virchow, who probably described the first case of subdural hæmorrhage which he classically termed pachymeningitis hæmorrhagica, the causative factors still remain a mystery and the theories of many observers offer no satisfactory explanation.

As stated by Dandy,<sup>2</sup> the frequency of subdural hæmorrhage is probably greater than the few reported cases would indicate and perhaps half of all cases are actually presumed to be intracranial tumors. The recognition may indeed be difficult since it may be entirely unsuspected or perhaps mistaken for a mild concussion with transient mental disorders. Some cases may even present signs and symptoms which are confused with the mental behavior of an alcoholic, particularly if no history of trauma is obtainable. The fact that a survey of the literature reveals a striking variety of clinical features, from a few vague mental symptoms of psychoneurosis to a composite picture of an increased intracranial pressure, emphasizes the possibility of error in diagnosis. Horrax<sup>3</sup> pointed out that in certain cases the advance of the process with its resulting mental complications does not appear to have a surgical bearing. Such patients may end their career in an asylum and the old organized clot is discovered only after post-mortem examination. On the other hand, a certain group simulates a fairly localizable brain lesion which demands surgical intervention and the clot is disclosed only at operation. It may not be possible, therefore, to make an absolute diagnosis except by operative exposure which is justified solely by the urgency of the case. The surgical treatment, dramatic and formidable procedure as it may seem, carries with it a certain indeterminable hazard of a cranial operation, and is oftentimes held in abeyance by the surgeon, pending a more accurate means of diagnosis, the lack of which frequently sends the case, perhaps too late, to a recognized neurosurgical center for intracranial exploration.



## TRAUMATIC SUBDURAL HÆMORRHAGE

By nature of its localization and subsequent effect upon important areas of the cerebral cortex, the clinical syndrome due to subdural hæmorrhage may give rise to operative indications in the treatment of head injuries, which are a compromise between the acute symptoms of brain compression and the remote sequela of a definitely surgical lesion of the brain manifesting itself in the form of cortical irritation. The former is not an uncommon occurrence in the accident wards where the indication for decompression is generally, if not routinely accepted in all types of acute head injury involving the intracranial contents. Briefly, these indications are (1) simple or compound depressed fracture of skull which threatens immediate or remote injury to the underlying brain, the elevation of the depressed fragment being indicated; (2) contusion and laceration of the brain with cerebral œdema and increasing intracranial pressure which demands prompt subtemporal decompression, and (3) extradural, middle meningeal hæmorrhage which calls for immediate control. Aside from one or a combination of these types, subdural hæmorrhage, when recognized as a post-traumatic lesion either early or after a latent interval, is a positive indication for surgical treatment. The operation *per se* is considered devoid of risk and comparatively without mortality as in forty cases reported by Dandy. As a rule, the prognosis after surgical removal of clot is entirely satisfactory and with complete restoration to health of those patients who otherwise might have died or survived with the stigma of being mentally defective.

To stimulate a more frequent recognition of this hæmorrhagic intracranial lesion following a trivial head injury, the following case history in chronological sequence is presented.

CASE I.—Mr. B. H., white, aged fifty-three, was first seen in the evening of November 5, 1933, with loss of speech and rather strange acts suggesting some form of mental derangement. He was aphasic and uncoöperative at that time. The only history obtainable was the mere statement volunteered by his family that he had been "drinking." Beyond the fact that he was a chronic alcoholic and had had facial erysipelas in 1927, the past medical history was essentially negative and the family history was likewise unimportant. He was a moderately well built, adult male who failed to respond to simple commands, failed to coöperate and was content to lie quietly and gaze upward. His attention could be attracted with difficulty by slapping or making finger motions. He grasped objects placed in his hands. There was no pupillary irregularity and no nystagmus. His face was flushed, his breathing was regular and his general appearance was like that of a man suffering from hysteria. Except for a slight bruise over the occiput and a few ecchymotic spots on the left arm and left shoulder, further physical examination was almost entirely negative. There was no ankle clonus and no evidence of paralysis. Babinsky and Kernig signs were both negative. The temperature was 101°, pulse rate 86 and respiration 24. The blood-pressure was 130 over 68.

On the following day he developed convulsions at about thirty-minute intervals. In view of the continued elevation of temperature of 102°, another careful examination was made to find any infective process. None was found. Upon investigation of the cause of his bruises, it was learned that he had been struck by an automobile the day before he lost his speech and was admitted to a local hospital in a fully conscious state. He was held there for twelve hours' observation during which time no evidences of serious injury were noted except slight bruises on his left arm and shoulder and a small con-

## ALAVA AND STAT

tused wound of the scalp over the occipital region. He had also complained of slight headache but otherwise seemed perfectly normal. He was discharged after signing a release following which he presumably walked home, a distance of over a mile.

Because of this information, the patient was immediately sent to St. Francis Hospital and was admitted November 7, 1933, for further observation. During his stay in this hospital, the aphasia persisted and his convulsive attacks recurred daily with increasing frequency. The character of these seizures was definitely Jacksonian in type starting with twitchings of the right side of the face and rapidly extending down to the right arm and entire right side of the body with the head drawn towards the same side,

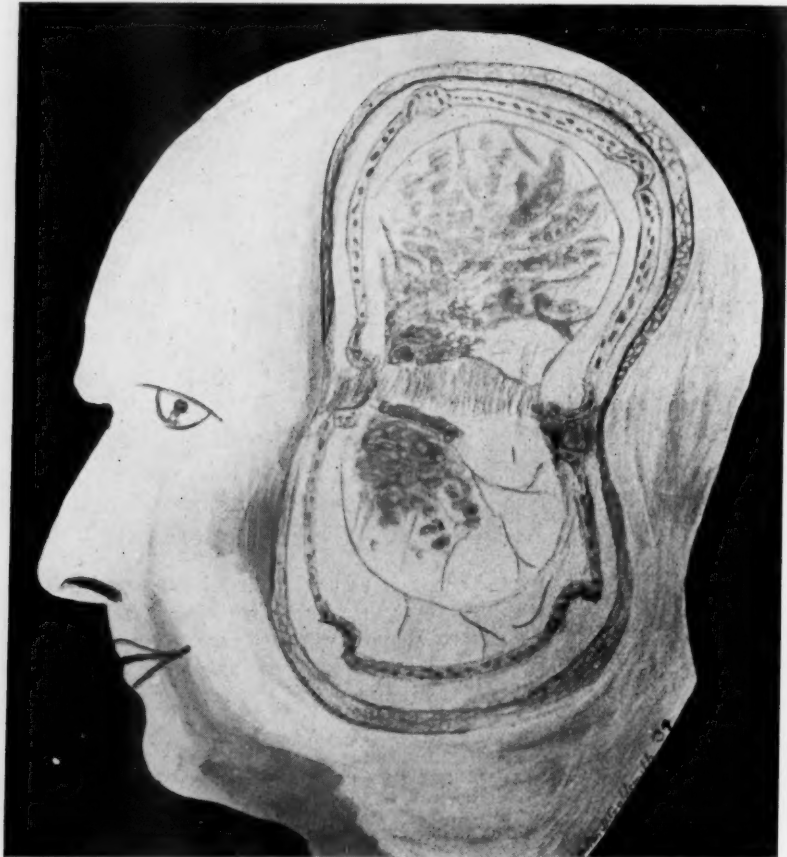


FIG. 1.—Diagrammatic sketch showing subdural clot, partly organized and adherent to reflected flap.

and with only partial loss of consciousness. The convulsive movements lasted from three to five minutes followed within half an hour by two or three other attacks in succession. During the interval, he continued to appear dull and apathetic but showed no signs of stupor.

The only subjective symptom of note was headache which apparently was not severe and which he, in spite of his aphasic state, seemed to clearly indicate by gesture, as localized over the frontal and left parietal region. He had had no vomiting; was not able to eat nor drink without help. Furthermore, he had some difficulty in understanding the written or spoken words although he responded to loud sounds and at times imitated tongue protrusion.

## TRAUMATIC SUBDURAL HÆMORRHAGE

Neurological examination showed the pupils equally round and regular but responding sluggishly to light. The eye-grounds showed slight hyperæmic vascular markings of the left disc, otherwise seemed normal. A definite right facial palsy and weakness in the grip of the right hand were present. His right biceps reflex was exaggerated over the left, and this, plus transient bilateral clonus and positive Babinsky on the right side, were the sole neurological findings. An X-ray of the skull revealed no fractures. Lumbar puncture disclosed a hæmorrhagic spinal fluid under no increased tension.

The blood Wassermann was negative. Hæmoglobin concentration was 85 per cent.,

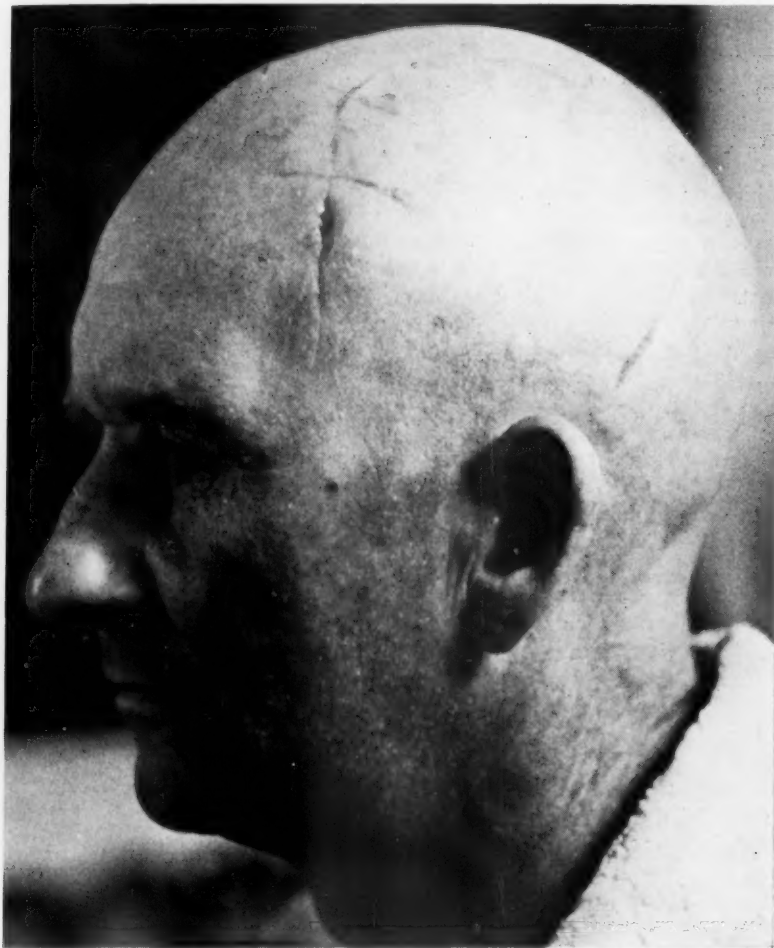


FIG. 2.—Patient twenty days after operation.

red blood-cells numbered 4,420,000 and white blood-cells, 9,600 with 80 per cent. polymorphonuclears. The urine showed no glycosuria, but a slight amount of albumen and a few finely granular casts. The period of observation lasted one week during which his temperature ranged from  $99\frac{2}{5}$  to  $102^{\circ}$  rectally. Repeated blood-pressure readings showed an average of 132 systolic.

The persistence of focalized convulsions and the definitely localizing value of his aphasia (the patient being right-handed), the right facial and arm palsy coupled with the finding of hæmorrhagic spinal fluid, all seemed to indicate that a hæmorrhage had occurred in the region of Broca's area on the left hemisphere. It was assumed that this

## ALAVA AND STAT

hæmorrhage was subdural or perhaps cortical and had clotted, since there was no evidence of further bleeding. In addition, the patient's cerebral mechanism was evidently compensating for whatever hæmorrhage had occurred. Presumptive diagnosis of subdural hæmatoma was therefore made. The treatment in the meantime was concerned chiefly with maintaining nutrition and combating dehydration by intravenous and subcutaneous injections. This we believe was not contra-indicated since there were no signs of increased intracranial pressure. After the use of medication to control convulsions had failed and the patient showed no signs of improvement, either with his aphasia or his apparent mental torpidity, surgical removal of the clot was deemed advisable.

November 13, 1933, exactly nine days after receiving his injury, an osteoplastic craniotomy was done under general anæsthesia. An adequate bone flap was turned down over the left temporoparietal region to expose the rolandic area. (Fig. 1.) The dura was found under slightly increased tension and had a dark appearance underneath. On opening, a sudden gush of dark bloody fluid escaped which was aspirated. Partly organized and loosely adherent pieces of clot were found under the dura and directly over the neighborhood of the speech area just above the Sylvian fissure. The clot had no membranous covering and the hæmorrhage had apparently diffused and involved a wider area of the brain cortex beneath the pia since all the presenting convolutions anterior and posterior to the rolandic fissure were faintly discolored with extravasated blood, extending beyond the limit of the dural flap. The clots were carefully peeled off and removed, and the exposed surface of the brain was gently irrigated with warm normal salt solution. A small rubber tissue drain was inserted underneath the dura. The composite flap was replaced and the wound closed in layers. The operation lasted two hours and thirty-five minutes and was well tolerated without signs of shock.

The immediate post-operative reaction was good, the patient having regained consciousness within six hours. There was profuse serosanguineous discharge during the first day. After forty-eight hours the drain was removed. The temperature curve started to drop beginning the third post-operative day and thereafter stayed normal. Except for slight headache, his recovery was smooth and uneventful. He had had no more convulsive attacks and gradually became brighter mentally. His aphasia began to clear and by the tenth post-operative day speech had improved to the extent of his being able to utter not only words but sentences with a degree of clearness and intelligence. His right-sided palsy also disappeared almost completely by the time he was permitted to be out of bed on the twelfth day. His convalescence being rapid and uninterrupted he left the hospital fully recovered twenty days after the operation. (Fig. 2.)

COMMENTS.—Chronic alcoholism was very probably a predisposing and a significant etiological factor in this type of hæmorrhage following an apparently slight head injury. Exactly where the bleeding originated is a matter of conjecture. It was sufficient to assume the proportion of causing, after a very short lapse of time, a marked disturbance of function in the speech and motor area of the cortex.

The character of the clot found at operation differed perhaps in gross appearance from the usual findings in the chronic type of subdural hæmatoma. It was not encapsulated nor covered by what Dandy termed neo-membrane. The greater bulk of the extravasated blood was fluid rather than the usual mass of clot. The short interval from the time of the accident probably explains the absence of a limiting membrane which had had no time to form, and the laminated appearance found in the senile inflammatory type of the true pachymeningitis hæmorrhagica was notably lacking.

A remarkable feature of the case was the total absence of signs of in-

## TRAUMATIC SUBDURAL HÆMORRHAGE

creased intracranial pressure by which this type of lesion is frequently and almost solely recognized. The patient at no time showed signs of actual or impending coma which depends to a great extent upon the amount and the persistence of the bleeding, resulting in a generalized brain compression. Instead of this pathognomonic sign, manifestation of a Jacksonian type of epilepsy was the outstanding feature and the only deciding factor which led us to resort to operative treatment.

A complete neurological examination was not possible as we were dealing with a subject who was temporarily deranged and hardly coöperative. Likewise, our attempt to make an accurate diagnosis and to properly localize the lesion was far from being thorough without the aid of a spinal air injection. Nevertheless, after having ascertained the findings later at operation, we doubted very much if an encephalogram could have been of great help in the final diagnosis upon which the surgical treatment was indicated.

We concluded from our experience in this case that, to a limited degree perhaps, it may not be so difficult to recognize this type of intracranial hæmorrhage, particularly when a history of previous head injury is available. The most valuable localizing symptoms and most significant focal signs are aphasia, convulsions of the Jacksonian type, and localized palsy, which, together with the presence of blood in the spinal fluid, presage the condition of subdural hæmorrhage and justify the surgical removal of the clot.

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## SUBTOTAL BILATERAL ADRENALECTOMY FOR HYPER-ADRENALISM (ESSENTIAL HYPERTENSION)

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FROM THE DEPARTMENT OF SURGERY, DECOURCY CLINIC

It is my purpose to set before surgeons the advantages of a surgical procedure that I have lately been using for the relief and cure of essential hypertension, based on the hypothesis that the cause of this condition lies in a hyperplasia of the medullary tissue of the adrenal glands under constant sympathetic stimulation, resulting in the secretion of excessive amounts of adrenalin into the blood-stream.

If this hypothesis be true, it would seem that the logical treatment for such cases is surgical removal of the excess amount of the overactive glandular tissue.

No novelty is of course claimed for the hypothesis itself with reference to the etiology of essential hypertension, although, as we all know, there are still some who do not accept it. The novelty lies only in the method I am about to propose; namely, subtotal bilateral excision of the adrenal glands, leaving not over one-fourth to one-third of each gland to carry on the work. This still leaves a good margin of safety, since it is admitted that one-fourth of one adrenal gland is fully sufficient for all the demands of normal living.

The operation of subtotal adrenalectomy, as performed by us, consists, then, in the removal of two-thirds to three-fourths of each adrenal. It is done in two stages, with an interval of about two weeks between operations. The portion removed includes both medulla and cortex and is taken from the part of the organ remote from the entrance of the blood-vessels.

The approach is made from the back through a kidney incision, the kidney being held down with a special retractor. The adrenal must be recognized and stripped clean of all fat and overlying structures. The portion to be removed is then clamped and excised, the raw surface being covered with a continuous chromic suture.

Spinal anæsthesia is employed and the blood-pressure is watched closely throughout the entire operation. If the fall is more than anticipated, ephedrin is promptly given and intravenous saline with adrenalin is always ready at hand in case of collapse. These patients, however, seem to tolerate spinal anæsthesia very well. To date we have had no alarming symptoms. The operation is not severe, and, aside from accidents, we consider it an entirely safe surgical procedure.

It is now about four months since I performed the first operation. Up to the present time I have operated on a total of eight cases, doing sixteen operations.

## ESSENTIAL HYPERTENSION

In every case the patients operated upon have been improved; that is, the symptoms of hypertension have disappeared. The blood-pressure has remained lowered in every case, the average drop and maintenance having been about 70 to 90 points systolic and 40 to 50 points diastolic.

The first patient operated upon, a case of malignant hypertension with a reading of 270/160, now has a pressure of 210/120. The five cases following this, with averages of 250/140 at the time of operation, now exhibit pressures of 160 systolic, and diastolic variations from 70 to 105. The more recent cases are all maintaining lowered pressures consistent with the initial drop.

It is probable that the chromaffin system, other than the adrenals, acts as a storehouse for adrenalin. For this reason we may expect a slight rise of blood-pressure after the patient returns to his duties. This may persist for several months, and then drops.

Of late we have been removing more of the glands in the more severe cases, but have had no untoward symptoms even when three-fourths of each gland was removed.

According to Goldzieher,<sup>1</sup> it has long been clearly demonstrated that an excessive amount of pheochrom tissue can produce spells of hypertension. Conversely, this author observed that the prevalence of pheochrom stimulation is evident in the history of almost every case of hypertension. It is his opinion, after more than twenty years' close observation, that the basic disturbance in genuine hypertension is a hyperfunction of the adrenals, and that this holds true not only for the essential but also for the renal type of hypertension.

I need hardly point out that precisely those factors which are everywhere recognized as responsible for states of hypertension are also known to increase adrenal activity, so that it seems very logical that we should find those states in association with that activity. We know, for example, that high-strung individuals, with an emotional, irritable disposition, with psychic instability, suffering with disequilibrium of other glands, or in a toxic condition from abuse of alcohol and tobacco, are the ones most subject to hypertension; and these are also the very individuals in whom the adrenal function is likely to be working overtime. There seems, therefore, every reason to regard the hypertensive picture as one of an endocrine dyscrasia, in which the adrenal glands are the responsible factor. A glance over the literature justifies this view.

As far back as 1903, the French surgeon Josué,<sup>2</sup> in a communication to the Société de Biologie, suggested the rôle played by the suprarenal capsules in the production of arterial tension and atheroma. "If one envisages adrenalin," he says, "as a product of secretion of the suprarenals, it is only one step further to think that these organs may play an important rôle in the production of atheromatous lesions."

It is thus clear that Josué regarded arteriosclerotic lesions as the result,

rather than the cause, of hypertension, and traced them both back to hyperactivity of the adrenals.

In the following year Josué's colleague, Vaquez,<sup>3</sup> proposed what he called "a new, hypothetical explanation of hypertension." "For a long time," said he, "I have been giving my attention to the view that hypertension is caused by substances capable of provoking excessive vasoconstrictor phenomena, and that these can be discovered only in certain products elaborated by the glands of internal secretion, and particularly the suprarenal glands."

Vaquez had only one anatomical observation of his own. That was in a patient with hypertension whose autopsy revealed a hyperplastic adrenal, on one side, transformed into a fatty adenoma. Before reaching this stage there had been a "hyperepinephria"—to use a term coined by Bernard.

Confirmatory evidence of this point of view was presented by Schur and Wiesel,<sup>4</sup> in 1907, and by Philpot,<sup>5</sup> in 1909, who found the adrenal medulla enlarged in nearly all of twenty-seven cases of hypertension on which he based a report. Goldzieher,<sup>6</sup> in 1911, wrote a monograph to add further proof to this conception and has continued ever since in his efforts to bring evidence of its correctness.

Nevertheless, the view that hypertension may exist independently of renal or arteriosclerotic changes and that the organs responsible are the adrenal glands met with determined opposition from a large number of laboratory workers, who contended that the presence of an excess of adrenalin in the arterial blood of individuals suffering with symptoms of hypertension had never been demonstrated.

Thus, Stewart,<sup>7</sup> Gley,<sup>8</sup> Hoskins,<sup>9</sup> McClure,<sup>9</sup> and others have insisted that even a physiological adrenalinæmia is unprovable, although admitting that adrenalin enters the suprarenal vein from the medullary tissue and that it can be recovered from the blood of the inferior vena cava.

To this chorus of dissenters, Pende,<sup>10</sup> of Genoa, that passionate disciple of the truth, retorted: "If it can be found in the vena cava, then how can it be denied that it exists in the general circulation, merely because our defective technic is not successful in discovering it when it is diluted in the great mass of the blood?"

In view of this controversy, it is a source of satisfaction to read that within the past few months reports have been received from two different sources that adrenalin has actually been detected in the arterial blood.

From Germany came the word that a group of Japanese workers headed by Ken Kuré<sup>11</sup> have found a means of identifying adrenalin in the bloodstream by a new technic which excludes oxygen during the blood examination, this gas having previously been found to destroy adrenalin in the blood before it could be measured. They state: "In the blood of persons with normal blood-pressure it is always possible to demonstrate a greater or less quantity of adrenalin. The blood in persons with essential hypertonia contains more adrenalin. This result shows that essential hypertonia is caused by hyperfunction of the adrenals."

## ESSENTIAL HYPERTENSION

About the same time, Viale,<sup>12</sup> of Genoa, announced the finding by himself and his pupil Crocetta of adrenalin in the blood, and even in the washed red corpuscles, which reacted positive to the Viale reaction for adrenalin. They found that if to an adrenal solution, even in a dilution of 1:30,000,000, there is added one drop each of saturated corrosive sublimate and of sulphanilic acid, with a few drops of potassium iodide, the solution turns to a rose color. By this means they succeeded in finding adrenalin in the whole blood of dogs in an average concentration of 1:400,000, and in dogs' serum in a concentration of 1:500,000, thus showing the red corpuscles to be richer in the hormone than is the serum.

The thesis I am upholding finds further corroborative evidence in the observation of Goldzieher that pheochrome tumors of the adrenal are apt to cause hypertension, vascular crises, cardiac hypertrophy and vascular changes. Pheochrome tumors accompanied by hypertension, often of a paroxysmal type, were reported by a number of other writers, among them Oberling and Jung,<sup>13</sup> C. H. Mayo,<sup>14</sup> Pincoffs,<sup>15</sup> Shipley,<sup>16</sup> Wilder,<sup>17</sup> Rabin<sup>18</sup> and Labbe, Tinel and Doumer.<sup>19</sup> After removal the hypertensive attacks stopped, and all their associated symptomatology—vomiting, tachycardia, dyspnea, *etc.*—ceased abruptly.

I also find it significant that Goldzieher and Sherman,<sup>20</sup> in a study of the adrenal veins, noted that the muscular tissue of these veins participates markedly in the hypertrophy of the organ in cases of hypertension. Allen,<sup>21</sup> who made similar studies, found the ratio of muscle to lumen twice as great in hypotensive as in normal subjects. This raises an interesting question with reference to the possibility of adrenalin itself exerting a hardening effect upon muscle in general.

In this connection the following facts are pertinent: It is a matter of general observation that hypertension becomes more common at the time of the climacteric, when the activity of the gonads is being withdrawn. Whether natural or artificial, the menopause brings the same picture of vasomotor disequilibrium. The gonads thus appear to be antagonistic with reference to the adrenals. It is interesting to observe that they are quiescent at the very time when the adrenals are most active; that is, before puberty and again after the menopause. Conversely, they are most active when the adrenals are least so. Now, during this period of greater adrenal activity, the uterine wall contains more fibrous tissue and less muscle; but during the active years of a woman's genital life, the muscular fibres of the uterus predominate and the connective tissue becomes relatively less.

There is an implication here that I should like to emphasize. It is this: If the wall of the matrix reacts in this way according to the greater or lesser activity of the adrenal glands, what is to prevent the logical conclusion that other systems too react similarly? The arteriosclerosis of old age might then, with perfect logic, be the natural result of hyperadrenalism following the climacteric, instead of being regarded as the cause of hypertension by certain writers that I have referred to.

On the other hand, there is an interesting synergism with adrenalin in another endocrine field; namely, the thyroid. Knowing more about the thyroid than any other endocrine gland, we are able to say from actual observation and experience that in certain pathological states the thyroid secretes an excessive amount of its normal product, thyroxin, with a resultant train of nervous symptoms, demonstrably due to this increased secretion circulating in the blood-stream. We know, too, that the thyroid condition producing this increased secretion and its train of associated symptoms is that of hyperplasia. To explain this, there is an increasing tendency to call in a disturbance of the vegetative nervous system. And we have successfully controlled this hyperplasia by resorting to thyroidectomy.

Are we not warranted in following the same logic with reference to the adrenal gland? We know that this gland secretes adrenalin. We know that in its states of hyperplasia a train of nervous symptoms appears, comparable to those of hyperthyroidism, and we have seen that we have excellent production of adrenalin secretion. We also know that because of the important network of sympathetic nerve fibres connected with its capsule, the adrenal has been called the brain of the vegetative nervous system.

For this reason it seems to me permissible for us to recognize an analogy between excessive activity of the thyroid, due to sympathetic stimulation, the result of which is hyperthyroidism, and excessive activity of the adrenals, due to sympathetic stimulation, the result of which is hyperadrenalism. There is a parallel here that is practically inescapable.

These, then, are the reasons that persuaded me to make an attempt to relieve the painful disturbances of hypertension by a resort to subtotal bilateral adrenalectomy. A few others have blazed the way. There are the cases of Galatà, of Pieri, and of Monier-Vinard and Desmarest, all reported within the last five years. Galatà's<sup>22</sup> case was so desperate that any kind of experimentation seemed justifiable. Yet the results exceeded his best hopes, all the symptoms disappearing, though the blood-pressure rose again at a later time. Pieri<sup>23</sup> reported gratifying clinical improvement in one of his two cases. In Monier-Vinard and Desmarest's<sup>24</sup> case, one entire suprarenal gland was removed from a woman who had suffered severely for ten years with hypertensive manifestations. The primary effect upon symptoms was excellent, although later the blood-pressure rose again. It is probable here that the removal of more adrenal tissue would have produced more lasting results, and in addition there is always the possibility, pointed out by Wiesel, Goldzieher and others, that accessory chromaffin tissue may be present in the body in sufficient amounts to compensate for the excised portions of adrenal gland. This is a subject that requires further investigation in the light of future experience with this method of treatment.

CASE I.—The first case submitted to this type of treatment was that of a married woman, aged twenty-seven, who came to the clinic first October 7, 1933, complaining of frequent vomiting spells with a sense of fullness in the head and attacks of dizziness. She gave a history of having been confined to bed for two months previous to observa-



# ESSENTIAL HYPERTENSION

tion. Her general appearance was that of a woman acutely ill. Omitting all but the essentials of the history, it may be said that examination revealed nothing to indicate the presence of either renal disturbance or arteriosclerosis. The blood-pressure upon admission was 245 systolic, 150 diastolic. Her breath was slightly acid, suggestive of acetone. There was no œdema. On admission she was given glucose to overcome her acidosis. Ten days later she was operated on, the first operation consisting of the removal of three-fourths of the left adrenal under spinal anæsthesia. (Fig. 1.)

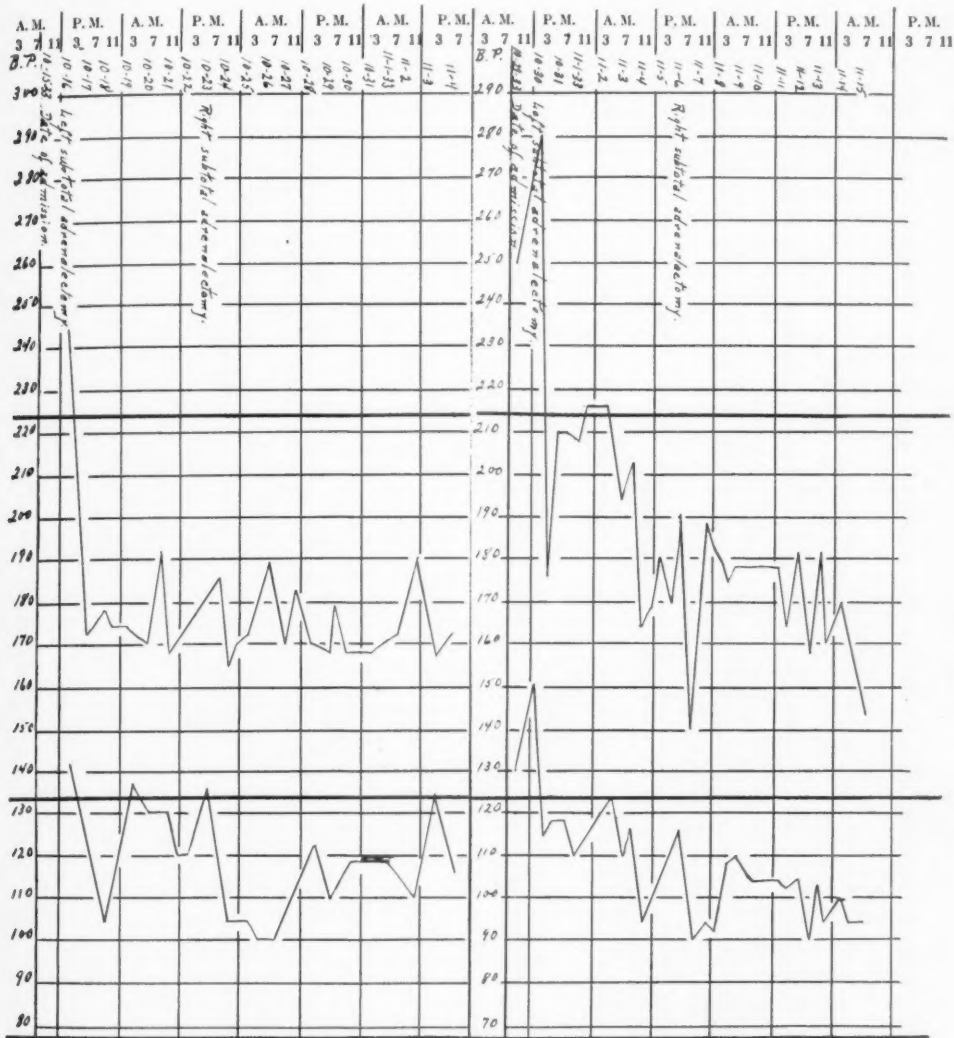


FIG. 1.—Case I.

FIG. 2.—Case II.

The systolic blood-pressure readings during the operation were: Start: 9:17 A.M. 220 mm. Hg.; 9:23 A.M. 230 mm. Hg.; 9:30 A.M. 180 mm. Hg.; 9:32 A.M. 140 mm. Hg.; End: 9:47 A.M. 220 mm. Hg.

On October 18, the day following, the blood pressure was: systolic, 176; diastolic, 130. On October 19, it was 174/115; October 20, it was 170/130; October 22, it was 164/114.

The second operation was performed October 23, 1933, at which time three-fourths

of the right adrenal was removed. October 25, the blood-pressure was 172/110, two days after operation. October 26, three days after operation, it was 165/108.

It is worthy of note that the diastolic blood-pressure, which had never gone below 140 mm. Hg. during a bed-rest of two months at home previous to operation, dropped to 108 three days after the second operation and has remained low ever since.

CASE II.—Although thus far no operations have been performed on patients with grossly damaged kidneys, the case I am about to report presented unmistakable evidence of arteriosclerotic changes of the vessels, with retinal hæmorrhages causing blindness of one eye. I am describing this case because it illustrates so well what bilateral partial adrenalectomy can do for the relief of this condition.

The patient, a married man of forty-six, was first examined by me November 13, 1933, complaining of severe headaches, dizziness and a sensation of blood rushing to his head—symptoms from which he had suffered for a year or more. Then on August 1, 1933, he experienced what his physician termed a stroke. From that time on he had difficulty in expressing his thoughts, and his right eye was sightless. During the interval between this event and his examination at the clinic, he lost forty pounds in weight. His father had died of apoplexy at the age of fifty-three. He was rather emaciated in appearance and walked with difficulty, leaning upon his wife for support.

Blood-pressure upon admission, 250/140. Urinalysis negative for albumin and sugar; its specific gravity was 1022. The blood urea-nitrogen was 19.6 mg., non-protein nitrogen 41.97 mg. per 100 cc. Differential blood count, 5,450 white cells, with 57 per cent. polymorphonuclears. The eye-grounds showed retinal hæmorrhage. Although the kidneys were negative, there was definite evidence of arteriosclerosis, noticeable in the arteries of the extremities.

Three days after admission a left subtotal adrenalectomy was performed. (Fig. 2.) Although spinal anæsthesia was used, the blood-pressure had meanwhile returned to its former level and the patient had completely recovered from the anæsthetic before the initial drop. When it came, it was rather alarming, the systolic pressure falling over 100 mm. Hg. and the diastolic over 40 mm., although the patient's condition was never precarious. The pulse pressure reading was very narrow for several days, after which the systolic pressure rose and the diastolic became more even, varying between 110 and 120 mm.

November 29, two weeks after the first operation, the right adrenal was partially removed. The reaction following this was comparatively slight, and from that time forward improvement became more marked until the patient was dismissed December 12, 1933. At this time the systolic pressure was 150 over 110, and the sight of the right eye had completely returned. The man left the hospital feeling entirely normal, except for a slight sense of weakness.

It is interesting to note that what appeared clinically as a spasticity of the cerebral vessels, with marked aphasia, entirely cleared up after the blood-pressure was reduced, and the speech became normal in less than four weeks.

I have, therefore, the impression that the pathological conditions we have encountered in the adrenals in the cases upon which we have operated, and the results we have obtained, clearly justify the performance of an exploratory operation with bilateral resection of the adrenal glands in severe cases of essential hypertension which do not respond to medical treatment. Nor do we feel that moderate changes of the kidney and arteries necessarily constitute a contra-indication, believing with Goldzieher that in most cases the adrenal changes come first and are at least to some extent responsible for the renal and arterial changes. We took this view in a case of uræmia complicating pregnancy, in which the history showed that hypertension existed three

## ESSENTIAL HYPERTENSION

months before albumin was discovered in the urine. That the kidney changes were secondary appears to be borne out by the results in this case.

In view of our experience, then, at the DeCourcy Clinic, I do not hesitate to say that the relief given to sufferers from hypertension by means of subtotal bilateral adrenalectomy has been a source of much satisfaction to me. I cannot refrain from expressing the hope that others will apply this method of treatment in severe cases of hypertension and publish their results, in order that the medical profession at large may have the benefit of a wider experience with a method that seems to give so great promise of future usefulness.

### CONCLUSIONS

(1) Essential hypertension is directly related to hyperplasia of the medullary tissue of the adrenal glands under constant sympathetic stimulation, with secretion of excessive amounts of adrenalin into the blood-stream.

(2) The adrenal glands have a large margin of safety. One-fourth to one-third of the glandular substance is sufficient to carry on the physiological activity of the gland.

(3) In a series of eight cases of essential hypertension, a total of sixteen operations of subtotal adrenalectomy proved remarkably successful in reducing systolic and diastolic blood-pressure and benefiting the condition of the patient.

(4) The beneficial results of subtotal bilateral adrenalectomy have persisted for months after the operations.

(5) The operation is best performed under spinal anaesthesia.

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JOSEPH L. DECOURCY

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## LIVER DEATHS (SO-CALLED)

RAPID HIGH TEMPERATURE DEATHS

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INTEREST in the results of gall-bladder surgery has, in my experience, passed through three stages.

In the first the important question was that of immediate post-operative life or death, *i.e.*, mortality.

With improvement in technic, in pre- and post-operative management, and in selection of cases, the mortality rate improved until one came to expect almost, as a matter of course, a satisfactory immediate recovery following the operation. This era of complacency was occasionally jolted by a realization of an increasing percentage of unsatisfactory final results which led to the second stage.

In the second stage the important question was that of the remote results, the relief, or non-relief, from symptoms, *i.e.*, morbidity.

But with more careful study, accurate diagnosis (exclusion of operation for non-calculous cholecystitis and for "gas on the stomach") and with earlier surgical treatment (before extension of disease to other organs or structures) the remote results improved.

The third stage (a return to the first with again the important question being that of mortality) gradually developed with a recognition of an increase in obscure, dramatic, immediate post-operative deaths, so-called "liver death," "liver shock," rapid high temperature.

Deaths following operation upon the biliary tract may be divided into three types: (1) those due to definite and distinct complications such as: hæmorrhage, shock, sepsis, peritonitis, pulmonary, cardiac or other accidents; (2) so-called "hepatic insufficiency," hepatico-renal, cholæmic or uræmic deaths with, or without, jaundice.

In the second: the symptoms generally do not appear before the fifth or sixth post-operative day and present the following characteristics: increase in temperature and pulse rate; abdominal distention, nausea, vomiting, hæmatemesis, melæna; oliguria which is progressive (albumin and casts always present, sometimes red blood-cells, urinary nitrogen decreased) œdema; delirium followed by coma; increase in blood non-protein nitrogen; jaundice and the icteric index (despite increase flow of a more watery fluid from the gall-bladder or ducts).

This clinical picture has been explained as failure of liver cells; "hepatic insufficiency" usually associated with uræmia—a "liver-kidney syndrome" (Helwig and Schantz, Jour. Am. Med. Assn., August 20, 1932; Surg., Gynec., and Obstet., 1933); (W. Bartlett, Jr., Surg., Gynec., and Obstet., June,



1933). (A similar belated post-operative syndrome has been considered as due to pancreatic involvement.)

(3) The tragic rapid high temperature deaths that, without apparent reason, like a "bolt from the blue," follow a simple operation upon an uncomplicated case differ strikingly from the second (so-called hepatic insufficiency) in the rapidity of the onset of the symptoms and death.

They are characterized by a temperature of  $102^{\circ}$  up to  $105-109^{\circ}$  F., with a slower increase in respiration and pulse, with vomiting, but not much pain, abdominal distention, obstruction or jaundice with sometimes a stage of excitement but usually increasing lethargy, semi-coma, coma and death within thirty-six to forty-eight hours. The white blood count is not increased, red blood count and hæmoglobin are high with increase in the blood non-protein nitrogen and sugar, but not in the icteric index.

The diagnosis is automatic because of the high temperature, the death within forty-eight hours and the absence of any reasonable explanation.

It is to this third (rapid high temperature) type of post-operative fatality that I shall confine my remarks.

Since my previous report in September, 1932, the following important articles upon the subject have appeared in the literature: Weiss, Samuel (*Am. Jour. of Surg.*, January, 1934, p. 96); Shearer (*ANNALS OF SURGERY*, December, 1933, p. 1114); Eiss (*ANNALS OF SURGERY*, September, 1933, p. 348); Graham, E. A. (*Radiology*, 1933, vol. 21, No. 2, p. 191), (four cases, only one with high temperature); Heyd, C. H. (*Jour. Am. Med. Assn.*, December 19, 1931, and *Surg., Gynec., and Obstet.*, September, 1933, p. 407).

In 1931 (*ANNALS OF SURGERY*, September, 1931, p. 363) ("Rapid High Temperature Death following Biliary Tract Surgery"), I reported cases from Mercy Hospital, Oshkosh, 1925 to 1931. I now present a similar study of such deaths occurring in the same hospital for the years 1931, 1932 and 1933:

	Operations	Deaths	Per Cent.	Rapid High Temperature	Per Cent.
1925 to 1931.....	549	72	13.1	17	23.6
1931.....	85	18	21.1	6	33.3
1932.....	52	9	17.3	1	11.1
1933.....	51	9	17.6	1	11.1
	—	—	—	—	—
	737	108	14.6	25	23.1

In order to minimize confusion with ordinary bacterial infections all cases with pre-operative elevation of temperature have been excluded as were, likewise, all cases that survived for more than forty-eight hours after operation. (These operations were performed by six surgeons in a general open-staffed hospital.)

## SO-CALLED LIVER DEATHS

### Typical deaths, after biliary-tract surgery:

In 1931, six cases:

4 calculous ectomies; 1 calculous ectomy and common-duct drainage; 1 biopsy for carcinoma of the liver.

In 1932, one case:

1 non-calculous ectomy; female, obese, history of many previous operations.

In 1933, one case:

1 non-calculous ectomy; female, additional appendectomy.

Impressions received after a careful review of all the recorded clinical data in these eight cases are: *Sex*.—All females. *Weight*.—Obese, 3. *Age*.—Youngest, 31 years; oldest, 64 years; 30-40 years, 2; 40-50 years, 3; 50-60 years, 2; 60-70 years, 1.

*Anæsthetic*.—General: ether, 7; gas, 1. Blood-pressure low in 6 cases; normal in 2.

*Blood chemistry*.—Non-protein nitrogen, pre-operative, 32.1; 44; 54; 54.5. Post-operative non-protein nitrogen, 57. *Sugar*.—Pre-operative, 76.9; 89; 102; 210. Post-operative, 122; 113. *Creatinin*, 1.42.

*Blood count*.—Hæmoglobin: 94; 92; 88; 78; 75; 66; red blood-cells, about normal. Post-operative in one case, 4,500 to 5,300. White blood-cells, no marked post-operative increase.

*Gastric analysis*.—In two gastric analyses hydrochloric acid was absent. In one case high temperature immediately followed intravenous injection of glucose.

*Urine*.—1 pyelogram and renal function, 43 per cent. Specific gravity, low; albumin and casts in 5. *Icteric index*.—plus 9 in one; plus 18 in one. Cholecystectomies, 7; cholecystostomies, 0; biopsy of liver, 1; calculous, 5; non-calculous, 2.

*Additional operations*.—Appendectomy.

At operation cirrhosis of liver mentioned in 1. At autopsy, in two cases, hæmorrhage and peritonitis were absent. Definite liver pathology sufficient to explain the fatal termination could not be demonstrated. The brain and cord were not examined.

Gall-bladder cholecystograms, 3; 2 non-visualized.

Previous history:

1 Four years before: laparotomy and vaginal, gall-stone palpated. No abnormal temperature reaction.

1 two years before, diabetes. One month before jaundice and temperature.

1 many previous operations: appendectomy, ovariectomy, round ligament shortening, non-calculous ostomy with rapid high temperature and recovery and last operation non-calculous ectomy. Probably a psychosis with obesity, hypothyroidism (?).

1 ten years before, nephrotomy for renal calculi; no abnormal temperature reaction.

### Typical deaths, not after biliary-tract surgery.

In 1931, two cases.

1 simple interval appendectomy for "chronic" appendicitis. Autopsy failed to reveal cause of death. 1 ventral hernia (subsequent to previous calculous ectomy) in elderly obese, deaf female. No autopsy.

In 1932, two cases.

1 simple interval appendectomy for "chronic" appendicitis. Autopsy failed to reveal cause of death. 1 ovarian cyst. No autopsy.

In 1933, two cases.

1 hysterectomy and appendectomy; death twenty-four hours later; temperature, 105° F. Autopsy showed fat necrosis of liver and ulcerative colitis. 1 simple fracture of the skull, contusion of brain. No operation. Death in six hours, temperature 108° F.

Impressions received after a careful review of all the recorded data in these six cases are:

F. GREGORY CONNELL

*Sex.*—Female, 4; male, 2. *Weight.*—Obese, 1. *Age.*—Youngest, 36 years, oldest, 79 years; 30–40 years, 1; 40–50 years, 3; 50–60 years, 1; 70–80 years, 1.

*Anæsthetic.*—General, 4; local, 1; no anæsthetic, 1. Blood-pressure: low, 5; normal, 1.

*Blood chemistry.*—Non-protein nitrogen, post-operative: 96; 29.7. *Sugar.*—Post-operative: 24, 83, 130.

*Blood count.*—Post-operative, hæmoglobin, 60; 65; 74; 101. White blood-cells, 15,000; 15,000; 9,200; 17,600; 24,000. Red blood-cells, 5,700,000; 3,500,000.

*Urine.*—Specific gravity low in 4; albumin and casts in 3; acetone in 1.

Three autopsies gave no clue as to the cause of death. The brain was not examined.

Typical reaction, but terminating in recovery.

In 1931, one case, after calculous ectomy; immediate post-operation, high blood sugar

In 1932, six cases.

1 after ostomy, non-calculous. 1 after ostomy, calculous. 1 after ectomy, calculous  
3 after ectomy, non-calculous.

In 1933, two cases.

2 after ectomy, calculous.

Atypical deaths.

In 1931, two cases.

1 calculous ectomy (in obese, blind, elderly lady) on seventh post-operative day, sudden high temperature and death. No autopsy. 1 calculous ectomy (in elderly thin woman; previous history of "chronic rheumatism," much cincophen). On tenth post-operative day, sudden high temperature and death. *Autopsy.*—Necrosis of liver, not visible before sections of organ.

In 1932, two cases.

1 ectomy, non-calculous, "hepatic insufficiency," tenth day. 1 ectomy, calculous with common-duct calculous, "hepatic insufficiency," seventh day.

In 1933, two cases.

1 ectomy, calculous, death in seventy-two hours. Autopsy, no cause found. 1 ectomy, non-calculous, death in seventy-two hours.

Recovery after high temperature following other than biliary-tract operations.

In 1932, two cases.

1 carcinoma of the stomach. 1 strangulated hernia.

In 1933, two cases.

1 appendectomy, interval. Palpation of, but no operation for, gall-stone in gall-bladder. 1 after gastroenterostomy for carcinoma. Forty-eight-hour temperature, 104° F. Seventy-two hours, 99° F.

Other interesting and more or less confusing observations were: Rapid death following biliary-tract operations, but without high temperature in two instances: one, twelve hour, "cerebral embolism" after calculous cholecystectomy; the second, twenty-four-hour "angina pectoris" after non-calculous cholecystectomy. No autopsies.

Damage to hepatic structure with death, but no high temperature occurred four times: (1) rupture of liver, traumatic; (2) a case of multiple biliary-tract operations, many firm adhesions, long difficult procedure with damage to liver tissue, but no high temperature; (3) and (4) two cases of toxic hepatitis (denatured alcohol) autopsy.

One case of rapid high temperature, one year after calculous chole-

### SO-CALLED LIVER DEATHS

cystectomy (probable stone in common duct) entered the hospital for observation, there was no operation and recovery within twenty-four hours.

Recovery, as a rule, followed if there was fall of temperature before the forty-eighth post-operative hour; but in two cases such a temperature fall was followed by a secondary rise and death, and in another case instead of being followed by recovery, such a fall of temperature (forty-eight hours, 103° F.; at seventy-two hours, 99°) continued low until death.

The six cases since 1930 of rapid high temperature deaths following non-biliary operations necessitate a correction concerning the statement in my previous article (*ANNALS OF SURGERY*, September, 1931). "A review of post-operative records in laparotomies for conditions other than biliary treatment failed to show similar temperature reactions."

This incorrect observation was probably based upon an incomplete review of case records.

Careful study of post-operative charts in the years 1931, 1932 and 1933 reveals eight rapid high temperature reactions in thirty-six deaths (22.2 per cent.) following 188 biliary-tract operations. There were also six such reactions in 300 (2 per cent.) deaths following 5,711 non-biliary-tract operations; similar cases will probably be discovered more frequently with more careful study of post-operative records.

In the last two years only two such fatal reactions occurred in eighteen deaths (11.1 per cent.) after 103 biliary-tract operations; while four occurred in 101 deaths (3.9 per cent.) following 3,284 operations upon other than the biliary tract.

Such deaths complicate the matter and increase the etiological possibilities. The cause is probably multiple rather than single. Among the possible etiological factors may be mentioned: Technical Errors.—Operative traumatism, denervation or devascularization of the liver. Too rapid decompression of the biliary tract, with circulatory or lymphatic changes such as: anhydremia, dehydration, portal obstruction or stasis, alteration in water, acid-base or sugar equilibrium; protein shock, allergy or anaphylaxis. Thyroid, adrenal, pancreatic or other endocrine dysfunction or imbalance. Disturbance in the "heat centre" of the brain; or in the liver.

An explanation based upon chemical, biochemical or metabolic disturbances seems much more probable than one depending upon microbic or bacterial infection.

Damage to the liver by traumatism, or by toxæmia, seems a very logical explanation and might be acceptable were it not for many confusing circumstances, for example: The fact that this tragic sequence does not occur in cases of definite traumatic rupture or non-operative damage to the liver or biliary system. Nor does it follow the technically difficult traumatizing, time-consuming, shock-producing, gall-bladder operation. Nor is it a frequent sequence in cases complicated by pre- or post-operative jaundice. And that, on the contrary, it does occur after simple quick uncomplicated operations upon the gall-bladder.

In this connection many cases with extensive perforation or gangrenous gall-bladder disease, but with practically normal temperatures, are recorded.

The enormous reserve power of the liver (70 per cent.) might be expected to prevent such sudden reaction, if the liver was the sole cause. Toxic destruction of liver-cells has been suggested as a cause, yet acute yellow atrophy of the liver is characterized by an afébrile course.

In this series, two cases of toxic (denatured alcohol) deaths (non-operative) that came to autopsy showed no marked hyperpyrexia.

Cincophen, a recognized cause of hepatic degeneration, has been given recent consideration in the literature with many case reports and was a preliminary factor in only one of our cases and in this instance the rise in temperature and death was atypical in being delayed until the tenth day after operation. (Autopsy showed typical area of liver necrosis.)

Lungberg and associates failed to show any great alteration in function after interference with the generous nerve supply to the liver.

Graham and Cannell (Brit. Jour. of Surg., April, 1933) report one case of ligation of the hepatic artery and a review of twenty-five similar instances from the literature fails to disclose any case of rapid high temperature death.

Shann and Fradkin (Jour. Am. Med. Assn., September 9, 1933) discuss the literature and report one case, again without any high temperature reaction.

Studies of the temperature of the liver as compared to other organs by Ito (Zeit. f. Biol., vol. 38, 1899) revealed that the duodenum has the highest temperature in the body, that the temperature of the blood in hepatic veins is higher than that of the portal vein, indicating an active heat production by the liver.

"Temperature of the Body in Diseases of the Liver," Goebel and Kanof (Med. Jour. and Rec. New York, February 15, 1931) in a study of 172 cases of liver disease found a high temperature very unusual.

Post-operative heat stroke has been considered by Reginald Cutting ("Principles of Pre- and Post-operative Treatment," Am. Jour. of Surg., September, 1931, p. 624) who collected twenty-six cases, only a few operations upon the biliary tract. At autopsies there were no significant findings.

In a more recent report of four cases, only one followed biliary-tract surgery.

After fracture of the skull ante-mortem rises in temperature have been frequently noted, the cause is unknown, but generally considered to be due to disturbance of the heat regulatory centres of the brain. In seventy-two fractured skulls Wilensky found high temperature in 21 per cent. In our one such case death was too rapid to admit of the possibility of an infective causative factor. A similar condition is found in post-operative thyroid crisis.

The decrease in such fatalities following goitre surgery, since the introduction of pre-operative management, is striking, and might serve as a hint in the subject under discussion.

Fat embolism should be considered in every case where there are grave



## SO-CALLED LIVER DEATHS

or unusual symptoms following trauma, whether the trauma of fracture, concussion, concussion, intravenous therapy, delivery or operation.

The occurrence of a "salt fever" is a well-recognized clinical phenomenon. Such a reaction may follow not only injection of salt, but also injection of dextrose or glucose, or of metal or colloids. It has also been explained by irritation of the heat centres by chemical products, hydrogen ion concentration, the temperature of the solution, the rapidity of the injection, *i.e.*, "speed shock" or impurities in the solution from the rubber tubing, stopper or glassware and to "pyrogen" (a soluble filterable product of bacterial origin).

The sudden rise of temperature that characterizes many diseases, differs in, usually, being accompanied by a chill and in not being followed by rapid death.

The similarity of these rapid high temperature deaths in fracture of skull, heat stroke and fat, or other embolism in which death is attributed to disturbances of the cerebral heat regulating centre, with the absence of extracranial evidence of pathology, coupled with the wonderful reserve store of liver tissue and with the absence of such symptoms with definite traumatic or toxic destruction of liver, suggest the possibility that such fatalities may be of extra hepatic origin, with possibly an important cerebral factor.

*Treatment.*—Pre-operative, at operation and post-operative. Pre-operative precautions include: all measures that may be routine before any or all operations, special preparatory details concern various liver-function tests. Such tests are more or less unsatisfactory because of: (1) the large margin of safety (70 per cent.) of liver tissue; (2) the multiplicity of functions performed by the liver: metabolic, secretory, excretory, detoxicating, blood coagulation and water metabolism. One test usually gives information concerning but one particular function.

The degree of pigment metabolism (icteric index or Van den Bergh) is informative, but as practically none of these cases has either jaundice or subjaundice, it is not of great help. The excretion of dye has been utilized by Abel and Rowntree, by Rosenthal, Graham and many others. Graham delays operation if there is 40 per cent. or more of dye (phentetiothalein) retention. The practicable combination of dye retention with intravenous cholecystography has directed favorable attention to this method.

X-ray visualization of liver or spleen by use of a contrast solution of "thorotrast" is in the experimental stage.

The galactose test is helpful and is meeting with seemingly increasing acceptance.

Roe and Schwartzman (*Am. Jour. Med. Sci.*, September, 1933) suggest estimation of the galactose content of blood as well as that of the urine.

Renal function (because of the recent attention directed to uræmia in cholæmia) should be given careful check-up.

Acid-base balance of blood should be noted before operation for comparison with post-operative estimates.

McQuiston (Mayo Clinic) has shown that the relationship of arterial hyper- or hypotension to surgical risk is not very important.

Because of the occurrence of rapid high temperature death following non-biliary-tract operations, it would seem eminently sane and rational to prepare as a routine every operative case in anticipation of such a possible complication by: (1) decreasing biliary stasis; (2) combating dehydration; (3) increasing storage of glycogen in the liver by glucose saturation.

At operation, gentleness, careful rapidity, avoidance of cooling exposure and trauma. Omission of additional pelvic or appendix operations, unless positively called for at the time. (Despite the fact that this syndrome usually occurs after easy, simple, satisfactory operations upon uncomplicated cases.)

Post-operative treatment, after the emergency has arisen, seems less satisfactory than does prophylaxis before the operation. There are no indications as to which case may, or may not, develop this fatal high temperature.

An early temperature rise is not uncommon, but usually subsides before forty-eight hours.

The underlying principle will be to combat dehydration by water; combat acidosis or alkalosis by dextrose, chlorides, or Hartman's, Buffer's solution; combat gastric retention by duodenal tube.

After the development of the rapid high temperature syndrome, the above principles are continued.

The water, acid-base, and glucose balances are corrected or maintained; adrenalin, Lugol's solution, insulin have been given.

Sonderregger (Schweiz. Med. Wchnschr., August 8, 1931) in speaking of the strikingly similar condition, heat stroke, suggests intravenous injection of hypertonic saline solution. Spinal puncture on the same physiologic basis might be performed.

On the whole active "treatment" seems rather inefficient, occasional cases seem to recover in a similarly unknown manner to that in which they arise.

But our experience certainly gives reason for continuing the suggested line of pre-operative or prophylactic management, and for its extension to other than biliary-tract cases.

*Summary.*—(1) Interest in results after biliary-tract surgery has passed through three stages. (a) The immediate result (life or death) mortality. (b) The final result (return of, or freedom from, symptoms) morbidity. (c) Again as in (a).

(2) Deaths after biliary-tract operations may be divided into three types: (a) Due to definite surgical complications or accidents. (b) Due to so-called hepatic insufficiency—fifth to sixth day. (c) Rapid high temperature deaths, within forty-eight hours.

(3) Report of rapid high temperature deaths of 1931, 1932 and 1933.

(4) Correction of statement in previous report (ANNALS OF SURGERY, September, 1931) "A review of post-operative records in laparotomies for conditions other than biliary tract, failed to show similar temperature reactions."

(5) Report of rapid high temperature deaths after non-biliary-tract operations.

## SO-CALLED LIVER DEATHS

- (6) Observations upon atypical cases.
- (7) Reference to recent literature.
- (8) Discussion of possible etiological factors.
- (9) Treatment before, during and after operation.

### CONCLUSIONS

Rapid high temperature deaths follow operations upon other than the biliary tract, probably more frequently than is supposed.

Because of this fact with the well-recognized excessive reserve in the liver, and the rarity of this sequence in definite traumatic or toxic damage to the liver or in the presence of jaundice, coupled with repeated failure at autopsy to find sufficient liver pathology to explain this rapid death;

One would seem justified in suggesting that the fatal syndrome is perhaps not hepatic but extrahepatic, with possibly an important cerebral factor.

Autopsies should include a careful examination of the brain.

Preventive treatment consisting of pre-operative saturation with sugar and water seems to have been helpful in reducing the sequence after biliary-tract operations.

As the usual liver function tests tell but a part of the story of hepatic sufficiency, such preventive measures are recommended (regardless of the hepatic tests) before all operations (in non-biliary as well as in biliary-tract surgery).

## MALIGNANT TUMORS OF THE LARGE INTESTINE \*

PATHOLOGICAL ASPECTS OF 210 CASES COMING TO NECROPSY

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RECENT reports concerning the prognosis of malignant growths of the large bowel show a distinctly favorable trend,<sup>3, 4, 5</sup> and in an effort to evaluate the pathological significance as well as the constantly improving methods of diagnosis and treatment of this serious condition, it has seemed worthwhile to review a large series of cases in which complete necropsy reports are available. The findings upon which this report is based are taken from a series of 210 cases of malignant growths of the colon which came to autopsy in the pathology department of the University of Minnesota up to July 1, 1933.

The early diagnosis and early complete removal of malignant tumors, wherever their location, determine for the most part the percentage of cures which can be obtained. This is especially true in tumors of the colon since metastasis and extension occur relatively late in the disease, thus usually affording ample opportunity for wide excision. Likewise it has been emphasized in many reports<sup>1</sup> that in spite of lymph-node involvement by the malignant process there are still possibilities for cure by wide excision of such invaded structures.

Cancer of the colon is not an infrequent disease as shown by numerous statistical studies; in fact, many of these studies show its incidence as being almost equal to that of cancer of the stomach. Yet in spite of this fact its diagnosis is too frequently made at such a late date that adequate treatment is relatively difficult to carry out. In carcinoma of the rectum it is especially unfortunate that the diagnosis is often made so late, because this region is so readily accessible to examination both by digital and proctoscopical methods. Rankin<sup>5</sup> has stated that the average patient with this malady has known of symptoms for about ten months, thus giving ample opportunity for metastasis and extension of the growth to take place.

### OBSERVATIONS FROM 210 CASES COMING TO NECROPSY

Up to July 1, 1933, there have been 21,648 autopsies done by the pathology department at the University of Minnesota and of these there are 723 cases in which the cause of death was carcinoma in the intestinal tract exclusive of carcinoid tumors of the appendix and neoplasms of the gall-bladder and pancreas. Their distribution is as follows:

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\* Presented before the Minneapolis Surgical Society, October 5, 1933.

# MALIGNANT TUMORS LARGE INTESTINE

Oral cavity (lip and tongue).....	42
Esophagus.....	57
Stomach.....	399
Small bowel.....	11
Large bowel and anus.....	214
Total.....	723

It is thus seen that carcinoma of the large intestine including the anus represents 30 per cent. of neoplasms of the intestinal tract, a figure which practically coincides with the results of other authors. In four cases the data were inadequate so these were discarded, making 210 cases in all. There was only one case of squamous-cell carcinoma of the anus in this series. This is a considerably lower incidence than one might expect. However, it probably can be explained by the fact that with such an external malignancy, autopsies are not as frequently obtained as in the case of lesions which are not visible. The frequency of this particular lesion as given by other authors ranges from 3 to 5 per cent. of colonic tumors. As to sex incidence, in this series 135 cases were in males, a ratio of 1.8 to 1. The preponderance of males is more apparent than real since autopsies in this age group are obtained in about this same ratio in the general run of cases. The highest age incidence was in the fifth and sixth decades, as indicated in the following table:

TABLE I  
*Age Incidence*  
(in decades)

10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
1	7	18	30	52	62	37	3

The oldest patient was eighty-four years, and the youngest fourteen years.

In this series of cases no distinction was made as to grading of the degree of malignancy, to any characteristics of cellular structure, or to the gross appearance of the lesion, since these points had little or no bearing on the facts to be emphasized.

The anatomical distribution of these 210 cases of carcinoma is as follows:

TABLE II  
*Location of Growth*

Cæcum	Ascend- ing colon	Hepatic flexure	Trans- verse colon	Splenic flexure	Descend- ing colon	Sig- moid	Recto- sigmoid	Rec- tum	Anus
26	5	10	8	7	11	36	33	73	1

A fact that impresses one as to the location of these tumors is that a majority of the lesions occurred at the two extremities of the bowel and again brings up the question of stasis as an etiological factor in the production of neoplasms. In the cæcum, large amounts of water are absorbed by a process of relatively rapid small movements so that the fecal stream here is



slowed down considerably. In the sigmoid and rectum storage of faeces takes place and stasis of course is more or less a physiological phenomenon. These facts certainly suggest that stasis plays some part by the chronic irritation which it produces. Of these 210 lesions, 107 occurred in the anus, rectum and rectosigmoid, regions which are readily accessible by the proctoscope, and an additional thirty-three were located in the sigmoid, a place which frequently can be visualized, so that well over half of all of these tumors of the colon could be diagnosed by inspection alone. This is an important fact when one considers the high incidence of cases which come undiagnosed to surgery or necropsy.

The importance of metastasis in the consideration of any malignant tumor needs no emphasis. In this group of cases some degree of extension of the growth took place in 115 of the 210, and in the remaining 95 the lesion was found at autopsy to be completely localized. Metastases occurred most frequently in the liver (sixty-seven cases), next in the regional glands (sixty-six cases), and finally in distant organs as shown in Table III:

TABLE III  
*Metastases in 210 Cases of Carcinoma of the Colon*

	Liver	Regional glands	Peritoneum	Pelvis	Lungs mediastinum	Brain	Adrenals	Fistulae Gastrocolic Recto vag.	Testes or ovaries	Heart
Cæcum (26).....	10	13	4		4	1				
Ascending (5).....	2	1	1							
Hepatic (10).....	3	6	1							
Transverse (8).....	3	3	1		1	1		1		
Splenic (7).....	1	1	1					1		
Descending (11).....	2	2	1				1			
Sigmoid (26).....	10	9	2	1	5	1	1		2	1
Recto-sigmoid (33)...	9	8	2	8	1		1			
Rectum (73).....	27	22	9	13	4	1	2	4	2	1
Anus (1).....		1								
Totals.....	67	66	22	22	15	4	5	2	4	2

Metastatic involvement of the spine was noted to take place in only three cases but since it is not routine to search for this type of lesion it is most likely that it occurred in a much higher percentage of cases than this figure would indicate. Metastases were also found in one instance each in the thyroid, kidney, cervical glands, appendix, pancreas, duodenum, spleen, gall-bladder, ureter, and axillary nodes.

Secondary deposits of tumor tissue took place with the same relative frequency as the occurrence of the primary lesion without regard as to the location in the colon of the primary lesion. In other words, there is no difference in the tendency to metastasize depending on the location of the growth in the right or left colon. However, when one considers the ninety-

## MALIGNANT TUMORS LARGE INTESTINE

five cases in which no metastases were discovered, an interesting fact is made evident. In the two flexures where considerable narrowing of the lumen of the colon takes place such as at the splenic area and the rectosigmoid juncture, metastases to distant organs are relatively less frequent. This is explainable by the fact that in these narrowed areas, the growth very soon causes obstruction and relief is sought or death occurs at a relatively earlier date than with lesions in other locations.

TABLE IV  
*Summary of 95 Cases with No Metastases*

	No opera- tion	Drainage operation (palliative)	Resection of tumor (curative)	Number and per cent. of total
Cæcum (26).....	3	4	2	9 or 34%
Ascending colon (5).....	2	0	0	2 or 40%
Hepatic flexure (10).....	3	1	0	4 or 40%
Transverse (8).....	1	2	0	3 or 37%
Splenic flexure (7).....	4	1	0	5 or 70%
Descending (11).....	2	4	1	7 or 63%
Sigmoid (36).....	5	3	3	11 or 30%
Rectosigmoid (33).....	7	11	5	23 or 70%
Rectum (73).....	7	13	5	25 or 34%
Totals.....	34	39	16	89
1 case died following closure of colostomy (three years).....				1
1 case died of apoplexy two years after Mikulicz operation.....				1
1 case died of renal insufficiency nine months after resection.....				1
3 cases died accidentally and tumor was found at necropsy.....				3
Total.....				95, or 45 per cent of all cases.

Besides the ninety-five cases listed in Table IV there were an additional sixteen in which the lesion was not large and the only evidence of extension of the growth found at autopsy was a few small glands immediately surrounding the growth. These seemed reasonably amenable to surgical removal so that it may be stated that in 111, or 52 per cent., of the 210 cases it appeared possible to completely resect the carcinoma. This is an encouraging fact when one considers the relative slowness of growth taking place in colonic malignancies and should be a factor in deciding upon the operability in questionable cases.

The seriousness of obstruction anywhere in the large intestine is well known because of its distressing symptomatology, its frequently disastrous termination, and the type of lesion which it usually denotes. In this series of cases, 81 per cent. showed obstruction which in many instances was complete, but in practically all cases contributed to the fatal outcome. This figure is considerably higher than in cases of this nature which are encountered clinically, but most of these individuals had had the disease so long that death

was due to far advanced lesions. Ulceration of the tumor was described in nearly every case except those which were discovered very early and this discovery was usually made accidentally. Spontaneous perforation of the growth took place in relatively few instances (thirty cases) in spite of high degrees, and in some cases of complete obstruction. This again emphasizes the fact that in slow-growing lesions where there is ample time for chronic inflammatory reaction to take place with its consequent fibrosis and scar formation, very high degrees of intra-intestinal pressure may be resisted. In rapidly growing tumors, early perforation is more likely to occur and when it does, rapid and widespread extension of the malignancy, if not early death from terminal peritonitis, may be expected. The distribution of these perforations corresponded more or less to the location of the lesion.

In 70 per cent. of cases some surgical procedure was carried out, but the following figures, of course, do not indicate in any way the operative risks or hazards encountered in this disease because they do not take into account any of the patients who left the hospital alive. Likewise the actual clinical status of the patient when first applying for treatment, many of whom were in a precarious condition, was not known. However, these figures do serve to point out some of the dangers which may be expected in operating on the colon and may especially assist in deciding the extent of the operation which is to be undertaken.

Of the 144 cases which came to surgery, in twenty-eight instances the tumor was resected in one or more stages, and in the remainder, palliative measures alone were undertaken. In thirty-nine of the latter, death resulted from untoward happenings since no metastases were present (Table IV), and resection of the lesion had been planned. The cause of death in the entire series of 210 cases is illustrated in Table V. Immediate surgical complications consisted mostly of general peritonitis which took place from one to eight days post-operatively. Several cases of shock here are included in this classification along with a case of ileus, in all of which there was reasonable evidence that peritonitis seemed to be the underlying factor. Technical surgical errors such as leakage of suture lines or slipping of a tube from the bowel allowing gross contamination of the peritoneal cavity, took place in eleven instances of death from peritonitis. Of these eleven cases, eight followed operations in which resection of the tumor was done along with primary anastomosis of the bowel ends. This fact tends to again bring out the point that graded procedures in the colon are usually the most satisfactory in the resection of malignant growths.

TABLE V  
*Cause of Death*

	Peritonitis	Exhaustion	Cardiorenal vascular	Pulmonary	Miscellaneous accidental
Surgical 144...	77	39	10	15	3
Non-surgical 66	30	26	7	3	0

## MALIGNANT TUMORS LARGE INTESTINE

In sixty-five cases exitus followed exhaustion from the deleterious toxic effect of the tumor and its metastases, and in lesser numbers cardiorenal vascular and pulmonary diseases were the cause of death.

A number of associated conditions were present along with the carcinoma of the bowel, and while these did not seem to be of direct influence in causing death, yet they contributed in many instances to reducing the operability rate and to a general lowering of the patient's resistance. These are grouped in Table VI.

TABLE VI  
*Associated Lesions*

Cardio-renal vascular	Gall-bladder disease	Hyper-trophic prostate	Acute appendicitis	Malig-nancy elsewhere	Localized polyposis	Diffuse polyposis	Divertic-ulæ
43	27	18	10	5	12	4	3

These figures again emphasize the fact that many patients with carcinoma of the colon are poor operative risks since at least a third of them harbor other diseases which render extensive surgical procedures impossible. These associated diseases are the commonest causes of deaths in patients dying in the fifth, sixth and seventh decades and no doubt represent the status of the average individual in this age group.

In sixteen individuals there was associated with the carcinomatous lesion one or more polyps, and in four of these cases the polyposis was diffuse throughout the colon from the cæcum to the anus. The relationship of these polyps to carcinoma has been proved<sup>2</sup> and there seems to be convincing evidence that if the patient harboring these tumors lives sufficiently long, malignant degeneration will eventually take place. The polyps in three of these cases were of the true adenomatous type and in the fourth were due to a long-standing chronic ulcerative colitis involving the entire colon. In one case of localized polyposis two carcinomatous lesions were found, each being a malignant degenerative process involving a polyp.

The presence of acute appendicitis in ten individuals is rather unusual, but is no doubt caused by one of two mechanisms. One reason is that there has been an extension of the inflammatory process from the lesion to appendix by means of a perforation or direct spreading. Less likely there is produced from the obstruction an increased intra-intestinal pressure which is transmitted to the appendix, distending it and predisposing it to inflammatory changes.

Five individuals in this series harbored malignancies elsewhere than in the colon, one each dying with distinctly separate neoplasms of the face, tongue, breast, kidney and knee-joint.

The possibility of colonic diverticulæ to undergo malignant change has been shown by other authors to be very slight, and the association of three such cases in this group is no greater number than one would expect in any series of individuals of this age who come to necropsy.

SUMMARY

(1) A series of 210 cases of malignant tumors of the large intestine is reviewed in this study. There was no preponderance of cases in one or the other sex. The highest age incidence was in the fifth, sixth and seventh decades. The oldest patient was eighty-four years, the youngest fourteen years.

(2) These growths anatomically were located with the greatest frequency at the two extremities of the colon. More than half of these tumors were located in the rectum, rectosigmoid, or lower sigmoid and theoretically at least, could be visualized through the proctoscope or sigmoidoscope.

(3) In about half of the cases coming to necropsy, the malignant lesion was mechanically resectable by surgical methods, since no extension or metastases was found at autopsy. About a third presented metastases in the liver or regional glands. Practically every organ in the body was involved in metastases in this series of cases. No significant difference was noted in the incidence of metastases compared to the location of the lesion.

(4) Obstruction took place in 81 per cent. of cases. The immediate cause of death was most frequently peritonitis or exhaustion but associated lesions such as cardiorenal vascular or pulmonary diseases, hypertrophy of the prostate, or acute appendicitis contributed to the low resistance of these individuals.

(5) Polyposis was present in localized or diffuse form in sixteen individuals, and in each one of these cases there was sufficient evidence to indicate that malignant change took place on a preëxisting benign polyp.

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## DEFORMITIES RESULTING FROM UNILATERAL SURGICAL TRAUMA TO THE EPIPHYSES

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UNILATERAL cessation or stimulation of epiphyseal growth as the result of disease or accidental or surgical trauma is not of infrequent occurrence. Growth disturbances unilaterally are known to occur in children in diseases such as rickets, renal rickets, dyschondroplasia, syphilis, epiphysitis, tuberculosis, smallpox,<sup>1</sup> osteomyelitis, bone abscesses and bone tumors. Lengthening of bones may be caused by osteomyelitis (Humphrey, 1862,<sup>2</sup> Speed,<sup>3</sup> Reschke<sup>4</sup>) and by stasis hyperæmia, angiectasis, hæmangiomas, and arteriovenous aneurisms.<sup>4</sup> Ulcers of soft tissue in the region of the cartilage plate are also said to cause stimulation of growth unilaterally. Conversely, contractures of the soft tissue may delay growth on one side and Reschke cites Billroth's case of ulnar deviation of the hand, due to contracture from a burn with stunting of growth of the ulna.

Accidental or surgical trauma in or near the epiphyseal cartilage plate may result in unilateral cessation of growth. Bidder,<sup>5</sup> in 1873, inserted needles into the cartilage plates of bones of dogs and whichever side of the cartilage plate was injured ceased growing. As pointed out by Cotton<sup>6</sup> and Speed,<sup>7</sup> cubitus valgus or varus may result from partial destruction of the lower epiphyses of the humerus. Speed<sup>7</sup> reports no damage to the epiphyses of the condyles of the humerus in children in early open reduction of fractures of the condyles when replaced and fixed by wire nails, the nails being removed in about three weeks. All cases of delayed open reduction, however, with replacement of the condyles and fixation with wire nails showed, after two to four years, definite distortion of epiphyseal growth with varying degrees of valgus or varus deformity. McKenzie<sup>8</sup> called attention to unilateral cessation of growth following surgical treatment of tuberculosis of the femur with resultant genu valgum. Elmslie<sup>9</sup> and Reschke<sup>4</sup> have cited deformities resulting from epiphyseal growth disturbances following fractures. Any fracture of a long bone through an epiphyseal cartilage plate, such as spiral fractures, T-fractures or "bumper" fractures, may result in growth changes of one side of the bone.

Another surgical procedure in children or adolescents which is capable of producing deformity is saucerization of the metaphysis too near to or through the cartilage plate. Too frequently, however, the epiphysis is destroyed unilaterally by the infectious process breaking through the cartilage plate and perhaps invading the joint as the result of too late or insufficient saucerization of the metaphysis. (Fig. 1.) Kennedy<sup>10</sup> points out that deformity may result also from epiphyseal disturbance due to the application of

tongs or pins in skeletal treatment of fractures in adolescents. Bone grafting, excision of exostoses, removal of foreign bodies, biopsies, capsulotomies, and the use of wire, brads, screws, or pegs through one side of an epiphysis—if not removed early—frequently produce unilateral delayed growth.

X-ray therapy and radium implants are reported by Desjardins<sup>11</sup> and Moore<sup>12</sup> as producing growth disturbances. Moore's case developed bow leg due to arrest of development on one side of the tibia at the site of the tumor mass. It is noted that radium implantation was done but also there was an exploratory operation which may possibly have damaged the cartilage plate.

*Types of Deformity.*—Cubitus valgus or varus deformities are seen following fractures of the condyles of the humerus. We have also seen varus



FIG. 1.—Unilateral cessation of epiphyseal growth in case of osteomyelitis. Incomplete saucerization of metaphysis two years previously. Clinically 15° genu valgum.

deformity following damage to the medial condyle produced at the time of saucerization of the lower end of the humerus for osteomyelitis with resultant premature ossification of the epiphysis. In the wrist radial or ulnar deviation frequently follow fractures through the cartilage plate, and manus extensa and valga may follow the laying of a graft across the epiphysis of the radius as is sometimes done to secure stabilization of the wrist in cases of paralysis, spasticity or tuberculosis.

In the knee the most common type of deformity is genu valgum or varum but Humphrey,<sup>2</sup> in 1858, observed a case of recurvatum in a girl aged fifteen. The knee was normal and when it was fully extended there was an angle of 120° with the thigh. He stated that the growth in the fore part of

## DEFORMITIES FROM EPIPHYSEAL INJURY

the upper epiphyseal line of the tibia had not kept pace with that in the hinder part. We have seen genu recurvatum in a girl of fourteen years (E.D.) who had a fracture of the femur five years previous which was treated, but at the same time she injured the anterior portion of the upper epiphyseal cartilage plate of the tibia resulting in epiphyseo-diaphyseal union anteriorly. Figures 2, 3 and 4 show the result of laying patellar grafts across the knee-joint and epiphyseal lines of growing bones following erosion of the joint. Frequently the patella is divided and laid across the denuded ends of the bones anteriorly; or the cartilage is removed and the patella replaced. If the leg is immobilized in slight flexion, the patella will frequently be found by lateral X-ray examination to be lying across the lower epiphyseal line of the femur, where if there has been surgical trauma, fusion and cessation of growth anteriorly will occur.



FIG. 2.—Postoperative fusion of knee, split patella used as graft anteriorly.  
FIG. 3.—(a and b).—Four years later. Cessation of growth anteriorly. 30° genu recurvatum.

Flexion deformities occur in the knee due to pressure from muscle pull of the hamstrings with diminished growth of the epiphysis of the femur and tibia posteriorly. This is occasionally seen in children in poliomyelitis, in severe arthritis, in tuberculous joints and following fusion of the knee when fusion has been allowed to occur in slight flexion rather than in extension. Figure 5 shows flexion deformity with epiphyseo-diaphyseal fusion posteriorly in a case of tuberculosis of the knee with subluxation of the tibia in which posterior capsulotomy was done four years previously. The flexion deformity has increased 10° in the past year.

In the ankle, varus or valgus deformities are usually seen following lateral epiphyseal trauma. Figure 6, however, shows an equinus deformity of a foot following manipulation and the surgical removal of a quantity of fibrous material from the joint posteriorly. Growth has continued anteriorly. Figure 7 is a slight calcaneous foot which followed surgical trauma to the

epiphyseal cartilage plate anteriorly in the laying of a graft from the tibia to the astragalus for stabilization of the ankle in a case of poliomyelitis.

*Prevention.*—Some of these deformities will be prevented if we bear in mind the time of ossification of the epiphyses of the long bones and avoid the prolonged use of foreign material, grafts and other trauma to the cartilage plate in children and adolescents. In most instances, osteomyelitis cases must have early and sufficient drainage of the metaphysis, but the periosteum should not be reflected too freely, neither should curettes be used in the region of the cartilage plate but the granulations wiped out as indicated by Speed.<sup>3</sup>

Ossification of the epiphyses of the long bones normally occurs at about



FIG. 4.

FIG. 5.

FIG. 4.—Two years post-operative fusion of knee. Patella was cut into small pieces and laid on denuded anterior surface of tibia and femur. 15° genu recurvatum.

FIG. 5.—Post-operative capsulotomy of knee in case of tuberculosis, because of flexion deformity and subluxation of tibia. Periosteum and capsule were elevated from posterior aspect of femur and flexion corrected. Four years later 60° flexion deformity of knee with epiphyseo-diaphyseal fusion posterior aspect lower femoral epiphysis; continued growth anteriorly.

the time of sexual maturity and occurs earlier in girls than in boys. Patterson<sup>13</sup> says: "All epiphyses appear up to six months earlier and fuse up to five years earlier in the female." He also states that the epiphyses fuse earlier in peasants and hard-working children, and later in the well-to-do. Ossification of the epiphyses is delayed in some cases of metabolic disturbances, and endocrinal dysfunction such as hypopituitarism and hypogonadism. In general, however, the epiphyses of the long bones fuse at approximately seventeen to nineteen years of age. Surgical trauma to the

## DEFORMITIES FROM EPIPHYSEAL INJURY

cartilage plate should therefore be avoided when possible in patients up to the ages of fifteen or seventeen, depending on the sex and habitus and röntgenographical findings.

*Correction.*—Speed and McKenzie checked the growth of bone by excision of the cartilage plate for correction of deformity, but unilateral cessation of growth of the epiphysis was first recently utilized by Phemister<sup>14</sup> for unilateral epiphyseo-diaphyseal fusion of radius and tibia. This same procedure of unilateral cessation of epiphyseal growth might be employed either by means of a graft or other surgical trauma to one side of the lower epiphysis of the femur or upper epiphysis of the tibia for the correction of knock-knee or bow legs in children of proper age. Osteotomies could then be avoided by this more simple procedure. It is believed that certain cases



FIG. 6.

FIG. 7.

FIG. 6.—Club foot, aged six. Numerous manipulations, 1930 capsulotomy and the removal of a quantity of fibrous material from the posterior aspect of the ankle-joint. Equinus increasing; continued growth lower epiphysis tibia anteriorly.

FIG. 7.—One year post-operative tibio-astragalus fusion of ankle-joint in poliomyelitis. Bone graft anteriorly. Mother states "The foot has grown in the back and not in the front which is just the opposite to what the doctor wanted." Foot fused in 5° equinus, now 10° calcaneal deformity. (See Case Report III.)

of hallux valgus and persistent metatarsus varus could also be improved by true lateral cessation of epiphyseal growth of the first metatarsal.

One must anticipate the amount of future growth by the age of the patient but should over-correction become apparent, a graft can be laid across the opposite side. Phemister reports that after twenty-six months the epiphyseal line of the radius had lost its obliquity following unilateral graft. Our case (T. P.) developed 15° recurvatum following discontinuance of brace in a period of one year; L. K., 30° recurvatum in four years; B. B. increased her flexion deformity 10° in one year; B. R., whose foot was placed in 5° equinus, now has 10° dorsal flexion fourteen months after operation; and



I. P. has  $15^{\circ}$  valgus of knee following osteomyelitis of tibia with continued growth on medial side over a period of two years.

Grafts are frequently now employed to secure ankylosis of joints in children, especially in the treatment of poliomyelitis and tuberculosis of the joints. Either the cartilage plate should not be traumatized and crossed, or the operator should anticipate the amount of growth yet to occur in the opposite side of the epiphysis and fuse the joint in a position that will give the optimum position for function when growth has ceased.

Correction may also be obtained by the continued use of corrective braces or casts and night molds. As pointed out by Delpech,<sup>15</sup> "Excessive pressure causes an arrest or diminution of the activity of the epiphyseal cartilage and conversely, diminished pressure produces hyperactivity."

#### CASE REPORTS

CASE I.—L. K., male, aged twelve, was admitted to the hospital with a chief complaint of an old injury to the left knee; cut with an axe above the patella in December, 1927. In January, 1928, pain and swelling and redness occurred. He was very sick for two weeks. Incision and drainage of the knee was done in January and a few days later, incision and drainage of the calf of the leg. He entered University Hospital December 12, 1928. Examination was essentially negative except for the left knee, which showed  $30^{\circ}$  flexion deformity, loss of motion, two-inch scar medial to the patella, knee tender to palpation, and wasting of the entire extremity. Questionable fibrous ankylosis of the knee. X-ray examination revealed flexion deformity, loss of joint space, old suppurative process of the knee-joint.

A Lovett case was applied January 7, 1929, and the leg straightened. January 25 he was transferred to contagious hospital because of diphtheria. February 5 he was transferred back to the bone and joint division and erasion of the knee-joint was done February 23, 1929. The ankylosis was broken down and erasion of the cartilage done. The patella was also denuded of its cartilage and split longitudinally. A bed was prepared at the front of the tibia and femur into which the patellar fragments were sutured. A long leg case was applied with the knee in  $15^{\circ}$  flexion. Post-operative röntgenogram in July, 1929, showed the femur and tibia in good alignment, slight flexion, bony ankylosis. The patient became weight-bearing gradually and discarded his brace the latter part of 1929.

In December, 1932, the patient returned to the hospital. He stated that "concave deformity" of the leg began about two years following operation and has continued. He now had  $30^{\circ}$  genu recurvatum and valgum, two inches of shortening. X-ray revealed bony ankylosis of knee with marked posterior bowing. He was admitted to the hospital for osteotomy, but developed scarlet fever. February 24, 1933, an osteotomy of the tibia and fibula was performed for genu recurvatum and a long leg case was applied. In June, 1933, the leg was solid, he was fitted with a brace, and discharged.

CASE II.—T. P. (No. 247956), male, aged nine, entered University Hospital in August, 1930, with a chief complaint of pain and swelling of the left knee. The leg was drawing up. Examination revealed a poorly nourished child who walked with a limp. The examination was essentially negative except for the left knee, which was markedly swollen, with local heat and limitation of motion and slight atrophy of leg,  $45^{\circ}$  flexion. X-ray reported destructive process of the lateral aspect of the lower end of the femur.

September 3, 1930, the knee was explored, a biopsy was done and fluid was sent for guinea-pig inoculation. A long leg case was applied. The biopsy showed chronic active tuberculosis. Pig inoculation reported positive for tuberculosis. September 11, 1930, erasion of the knee-joint was done. The cartilage was removed from the patella. It

## DEFORMITIES FROM EPIPHYSEAL INJURY

was cut into many small chips and laid over the raw bony surfaces of the femur and tibia. A case was applied with the leg in complete extension. The post-operative X-ray showed satisfactory results. September 20, 1930, the wound was healed and the patient discharged for three months. February 24, 1931, patient returned with a small draining sinus. X-ray showed bony ankylosis. Patient was fitted with a brace and night mold. September, 1931, there was good fusion and patient was instructed to continue with the brace. January, 1932, patient was discharged for one year without the brace. December 13, 1932, patient complained of some pain in the left knee, which showed genu recurvatum and a two-inch shortening. There was a question of a flare-up of the tuberculous process, and a question of an injury to the epiphysis. Röntgenogram revealed fusion of tibia and femur with  $15^\circ$  genu recurvatum. There had been growth posteriorly with ossification of epiphyses anteriorly. An osteotomy of the tibia for genu recurvatum was done January 7, 1933; March 12, 1933, leg was put in a walking case and May 3, 1933, fitted with a brace and discharged.

CASE III.—B. R. (No. 216351), male, aged eight, diagnosis of poliomyelitis with deformity. There was a flail left foot,  $1\frac{1}{2}$ -inch shortening of the left leg; he had worn braces for two years. He was admitted to University Hospital June 15, 1932, for arthrodesis of ankle. June 30, 1932, a long "J" incision was made, the subastragaloid joint was exposed and the articular cartilages removed. The articular cartilages were then removed from the ankle-joint with the exception of the medial malleolus. A small graft was then removed from the fibula and fitted into the lower tibial epiphysis anteriorly and into the upper surface of the neck of the astragalus. The wound was closed and a case applied with the foot neutral as to abduction and adduction and in  $5^\circ$  equinus. His convalescence was uneventful. Post-operative X-rays showed satisfactory result. July 11, 1932, the patient was discharged wearing a case. September 15, 1932, the ankle was solid clinically but not by X-ray, and a case was applied. November 23, 1932, there was solid fusion, a brace was ordered locked in equinus. April 12, 1933, there was excellent fusion but the heel was forward and tilted in dorsal flexion and some valgus. It resembled a condition produced by epiphyseal arrest of the anterolateral portion of the lower end of the tibia; but the deformity may also have been partially the result of slight displacement of the os calcis due to lack of normal Achilles pull and of delayed fusion of the subastragaloid joint. X-ray report was: "Epiphyseal arrest anterior portion of the distal epiphysis of the tibia. Growth has taken place in the posterior portion. Fusion of the ankle-joint. Unsatisfactory fusion of the subastragaloid joint." Discharged without a brace. September 13, 1933, there was  $10^\circ$  dorsiflexion deformity. The ankle was solid but patient had calcaneo-valgus foot.

### SUMMARY

Unilateral surgical trauma to the epiphyseal cartilage plate of the long bones of children and adolescents may result in deformity. Deformities thus produced may assume medico-legal significance.

The age and sex of the child as well as any endocrine imbalance should be considered before any operative procedure is done in or near the epiphyseal cartilage plate. If in doubt, the opposite extremity should be X-rayed for comparison. If grafts are laid across one side of the epiphysis of long bones of patients up to fifteen or seventeen years of age, due allowance should be made for continued growth on the opposite side.

Certain deformities of the extremities can be corrected by unilateral surgical trauma to the cartilage plate; or further deformity may be prevented by immobilization with corrective braces or casts, night molds, or leather cones with metal bars until growth has ceased or until the prevention of the deformity is assured.

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## OVERPULL DURING THE TREATMENT OF FRACTURES

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A REVIEW of the current text-books and literature dealing with the treatment of fractures reveals no clinical study of overpull. An occasional paragraph can be found that refers to it as "over-correction" or "distraction of the bone ends," regards it as an unfavorable displacement of the distal fragment, advises its correction, and considers the only possible harm to be soft-tissue intervention. At the Beekman Street Hospital, it is recognized as an occasional, important complication of the traction-suspension method.<sup>1</sup> It is our purpose to present a detailed study of twenty-three cases of fractures of the shafts of long bones in which overpull occurred, and by comparing their clinical course with that of a large series of the same type of case, similarly treated, over the same period of time, by the same surgical staff, to establish the serious status of this complication.

By this term is meant that condition found at a fracture site where, due to the traction force on the muscles of the extremity, transmitted through the distal fragment, an axial separation of the bone ends has occurred, recognizable on both anteroposterior and lateral röntgenograms. In a transverse fracture, visible interspace is apparent on both exposures; in an oblique or comminuted break, there will be noticed an interval between corresponding anatomical points. When angulation occurs, care must be taken not to confuse an apparent interspace with true overpull. In the latter, the axial alignment is characteristically good.

Table I is a tabulation of the location, type and stages of healing of ten cases with overpull occurring in fractures of the shaft of the femur. These are averaged as a group with one common factor, and contrasted with a control group of forty-four other cases whose only common characteristic is the absence of overpull. These are consecutive cases, non-selected and apportioned only with regard to this single factor. The only conscious omissions from either group are children, since overpull did not occur among them, and those cases incomplete because of early demise, short hospitalization, or inaccessible röntgenograms.

A perusal of this chart makes it readily apparent that the elapsed time before the appearance of callus on the X-ray film and the establishment of firm union in these overpulled cases is twice that of the control group. There is an average increase in the period of hospitalization of 34 per cent. and a marked delay in the attainment of solid union. Furthermore, there are two cases of refracture in this small group with only one in the control group, more than four times as large. There were four local operative procedures

## LESTER BLUM

in each group, an incidence of forty per cent. among the overpulled fractures contrasting with that of nine per cent. in the others.

In Table II, by following the same method of differentiation, we have contrasted the clinical course of three overpulled fractures of the humerus with an unselected group of thirty-three cases in which this complication did not appear. The startling occurrence of an operative procedure in each of these three cases as well as the marked delay in the appearance of callus justifies the tabulation of this short series.

TABLE I  
*Fractured Femurs*

Case No.	Shaft type, loc.	Callus	Firm Union	Solid Union	Disch. from Hosp.	Comment
Case I.....	Trans.,up.	32nd day	102nd day	185th day	102nd day	Overpull on 11th day. Final result good.
Case II.....	Trans.,low.	39th day	131st day	270th day	162nd day	Overpull at 24 hours. Drilled at 111th day to stimulate callus.
Case III.....	Trans.,mid.	43rd day	77th day	230th day	85th day	Overpull at 4 days. End-result good.
Case IV.....	Trans.,low.	162nd day	Plated	390th day	270th day	Overpull on 6th day. Lane plating at 116th day.
Case V.....	Trans.,mid.	Absent at 164th day	210th day	294th day	185th day	Overpull on 7th day. End-result good.
Case VI.....	Oblique, middle	31st day	73rd day	First mention 2 yr.	101st day	Overpull at 18 hours. Operated elsewhere at 10 mos.
Case VII....	Trans.,mid.	31st day	61st day	365th day	109th day	Overpull at 17th day. End-result good.
Case VIII....	Trans.,mid.	62nd day	204th day	330th day	147th day	Overpull at 8th day. End-result good.
Case IX.....	Oblique, middle	12th day (same at 63rd d.)	(92nd d. re-broken) 154th day	320th day	202nd day	Overpull at 5th and 43rd day. Re-fractured 103rd day.
Case X.....	Trans.,up.	38th day	Plated	230th day	208th day	Overpull at 3rd day. Re-fractured at 72nd day. Open operations 77th day
Average for overpull cases above	8 trans. 2 oblique 6 middle 2 upper 2 lower	63rd day	119th day	290th day	157th day	Four open operations = 40%. Two re-fractured.
Average control 44 cases	Up. — 7 Mid. — 22 Low. — 15 Obl. — 19 Trans. — 16 Com. — 7	32nd day	54th day	110th day	102nd day	Four open operations = 9%. One re-fractured.

Table III represents a summary of ten overpulled cases of fracture of both leg bones occurring among a total group of ninety-one complete cases previously analyzed from this clinic.<sup>2</sup> It differs from the humerus and femur group studies above, in that the statistics for the control group represent the average for all cases of fractured tibias and fibulas including these cases overpulled in course of treatment. The same delay in callus formation, firm and solid union, is here evident.

Although aware of the logical pitfalls inherent in a statistical study of a comparatively small group of cases, we believe the figures composing these charts graphically summarize the serious nature of overpull. It is a condi-



# OVERPULL DURING FRACTURE TREATMENT

TABLE II  
*Humerus Fractures*

Case Number	Type Fracture	Callus	Firm Union	Solid Union	Operations—Remarks (not Débridements)
Case XI.....	Trans., lower	54th day	Plated	?	Overpull in E. T. Open oper. 18th day. Lane plate.
Case XII.....	Oblique., lower	48th day	65th day	?	Overpulled after 24 hours. Open oper. at 15th day.
Case XIII.....	Trans., upper	Absent at 36th day			Overpulled in emerg. tract. Eventual amputation on 36th day through fracture site.
Average control 33 cases	12-up, 16-obl. 17-mid, 13-tr. 4-low, 4-comm.	26th day Up. 1/3-27 d. Mid. 1/3-26 d. Low. 1/3-26 d.	37th day	42nd day	Two open operations = 6%

tion that, with the growing use of the traction-suspension method, warrants further study. Before recording the individual case histories, it would seem profitable to consider certain of the factors evident in the incidence, origin and adverse effects of this complication.

TABLE III  
*Fractured Tibias and Fibulas*

Case Number	Location	Callus	Firm Union	Solid Union	Comment
Case XIV.....	Oblique, lower	63rd day	False motion at 84th d.	164th day	Overpull at 48 hours. Eventual good result.
Case XV.....	Oblique, mid.	24th day	False motion at 78th d.	149th day	Overpull at 6th day. Eventual good result.
Case XVI.....	Oblique, lower	32nd day	59th day	123rd day	Overpull at 17th day. Fracture line still present at 4 months.
Case XVII.....	Trans., lower	88th day	False motion at 88th day	?	Overpull at 17th day. Discharged on 92nd day.
Case XVIII.....	Comm., mid.	Absent at 99th day	False motion at 99th d.	?	Overpull at 24 hour more marked at 17th day. Poor general condition.
Case XIX.....	Trans., middle	96th day	210th day	305th day	Overpull at 48 hr. Comp'd developed local osteomyelitis.
Case XX.....	Trans., middle	52nd day	Out of traction 88th d.	161st day	Also fr. femur same extremity. Overpull in emerg. traction.
Case XXI.....	Oblique, lower	145th day	False motion at 21 mos.	?	Overpull at 24 hour. Periarterial sympathectomy at 49th day.
Case XXII.....	Oblique, middle	92nd day	180th day	395th day	Overpull 6th day of skeletal traction.
Case XXIII.....	Oblique, lower	Absent at 63rd day	74th day	?	Overpull at 24 hr. Chancre appeared on adm. treatment. Wassermann neg.
Average control 91 cases	42 lower 31 middle 6 upper 12 spiral	40th day	50th day	Low.-57 d. Mid.-92 d. Up.-70 d. Spiral-84 d.	Group of fractures of both bones of leg analyzed and discussed in reference. <sup>2</sup>

*Incidence.*—It is readily apparent that axial displacement of the distal fragment can be caused only by traction on the enveloping muscles. Overpull occurs where excess force has been applied and, in this series, there

seems to be no constant relation to the site and type of fracture line. The preponderance of transverse fractures in the femur group appears balanced by the majority of the oblique kind among the tibias. The unfavorable effect of overpull should, however, not deter one from attempting to secure anatomical reposition and alignment. The other side of the picture is presented in an analysis of thirty-two cases of malunion in fractured femurs by Patterson.<sup>3</sup> Overlapping, bowing or angulation were present in all. This, again, seems to emphasize the exacting nature of the traction-suspension technic. The possible occurrence of overpull should no more serve as a deterring factor to its employment in suitable cases, than the absence of this complication in unreduced fractures would argue for systematic neglect.

In Table IV is recorded the lapsed time after the institution of traction, at which overpull was first noted in these patients. Three were overpulled in emergency traction and in 50 per cent. of all the cases, it appeared in the first forty-eight hours. One case in which re-fracture took place was overpulled for the second time in skin traction on the forty-second day; this is not here recorded. It is evident that the humerus cases were overpulled

TABLE IV

*Time of Recognition of Overpull*

Abscissa = Days of Traction

E. T. = Emergency Traction

	E. T.	1	2	3	4	5	6	7	8	11	17
Humerus.....	2	1									
Tibia.....	1	3	2				2				2
Femur.....		2		1	1	1	1	1	1	1	1

within twenty-four hours and that six of the ten tibial fractures were pulled apart within forty-eight hours. The femurs show an equal distribution in the first week. There would seem to be a direct relation between the muscle mass and the length of time before overpull is manifest.

*Origin.*—There is no exact means of immediately determining the optimum of pull for any given fracture. It varies with the individual muscular development, age, sex, general condition and degree of soft tissue trauma. This latter is not a simple matter to gauge accurately. As Böhler<sup>4</sup> has pointed out, extensive muscle injury may take place with any closed fracture, and comparatively little where the skin is broken through. In the case histories appended below, it is well to remember that ten pounds' Russell or balanced traction is equivalent in effective pull to over twenty pounds' skeletal and over thirty pounds' skin traction. In regard to the three cases overpulled in emergency traction, two were compounded with tissue damage to the small mass of muscle surrounding the shaft of the humerus, and the other was in severe shock with multiple injuries which necessitated his being left in the traction for several hours. Of the remainder, all but one femur, which was treated with Russell traction, were reduced by skeletal pull. The only instance of overpull by skin traction occurred following re-fracture in a

## OVERPULL DURING FRACTURE TREATMENT

femur originally overpulled on the fifth day. In the entire series, there is no instance of overpull due to manipulation under anæsthesia with plaster retention.

*Retardative Effect on Callus Formation and Union.*—It is not improbable that the regenerating cells in a fresh fracture site are no more pleased at being torn apart than were the hapless victims of Procrustes, the mythological father of traction devices. In an experimental study of non-union, Cowan<sup>5</sup> found that “—where gravity or muscular contraction produces tension on the developing granulations, the fibroblasts respond to this by the production of an abundance of fibrous tissue, the cells and fibres of which are arranged in the lines of tension and a fibrous band similar in structure to a tendon is formed.” In other words, tension on the regenerating tissue had a definite, unfavorable influence on its osteogenetic power. The microscopical report on tissue from between the fragments of one of the cases (No. IV) operated on resembles this description in that “. . . section shows spicules of dead and living bone lying in a bed of dense fibrous tissue . . . The marrow spaces in the field are small and filled with skeins of loose areolar tissue . . . here, also, the marrow spaces are lined with fibroblastic connective tissue. . . .” We have here some basis for entertaining the concept of a specific, injurious effect on the healing process at the fracture site, due to overpull.

Of relevant interest is the experience of orthopædic surgeons in bone lengthening. Abbott,<sup>6</sup> some years ago, in introducing his double Z osteotomy method, mentioned the delayed union in cases presented by Putti. Nevertheless, in his own series of adolescents and children the average time for firm union to develop in the leg bones was three months, and for solid union, six months. In a more recent communication from another source, Haboush and Finkelstein,<sup>7</sup> in which a series of seventeen cases of leg lengthening in patients aged nine to twenty-three with an average of fifteen years, was presented, there were four cases of delayed union and two of non-union. In this procedure bony contact is maintained during the course of overpull.

It is pure assumption to consider soft-tissue intervention as taking place in all, or even the majority, of overpulled fractures. This supposition would afford a simple explanation of the sequelæ, but it hardly accords with the facts. Of the four cases on which open, exploratory procedures were done, only one (Case XII) showed muscle between the fragments. Among the others, in addition to four (Cases IX, XVII, XX, XXII) whose overpull was successfully reduced in traction, the majority showed a distinct apposition of the bone ends when removed from traction and placed in plaster or caliper splints.

It is also customary to relate the slow healing of these fractures to the distance between the fragments. If this were a valid explanation, then the larger the gap, the poorer should be the result. In this connection, it is interesting to note that Case I and Case VII, which showed callus at the normal time and were clinically firm earlier than the average for the other

overpull cases, exhibited the largest defects. Furthermore, in Case XIX, where, after sixty-one days of separation, apposition occurred with removal from traction, there was no callus visible in the tibial fracture line at eight months despite a good fibular union. A similar situation is present in Case XVII. It would, therefore, appear that the usual explanations will not suffice.

In Table I, six of the overpulled cases are shown to have callus appearance times within normal limits, and in one, Case IX, it was visible at twelve days. However, in the latter instance, there was no increase in callus by the sixty-third day and a re-fracture occurred at the one hundred and third day with no gross trauma to account for it. Union was not firm until 154 days and the bone was not solid until more than ten months from the time of injury. In these six cases with visible callus at the normal time, there was exhibited the same marked delay in the attainment of clinical and solid union so characteristic of the entire overpull series. On reviewing these röntgenograms, the usual progressive increase in the amount of callus associated with gradual obliteration of the normal fracture line is not found. In fact, for months after the injury, the fracture site is visible usually as a central cavity within the abundant periosteal callus. (Seen in Case I at 4 months; Case II at 175 days; Case V at 174 days; Case VII at 9 months; Case VIII at 204 days; Case IX at 185 days; Case X at 181 days; Case XVI at 4 months; Case XVIII at 99 days; Case XIX at 8 months; Case XXI at 21 months.) This reminds us that the presence of calcium-impregnated tissue is only presumptive evidence of bone healing.

It is conceivable that mineral salts deposited in abnormal osteoid tissue would present a better structural appearance on the röntgenogram than is actually present. This possibility, coupled with the findings in the experimental work described above, offers a plausible explanation of the delay in healing of overpulled fractures.

*Prevention and Treatment.*—This complication is an insidious one in so far as it gives rise to no subjective symptoms (unusual pain was not noted at the time of overpull in any case), cannot be diagnosed by skin measurements and is recognizable only on the röntgenogram. It is apparent that the constant care necessary for the proper employment of the traction-suspension technic will tend to reduce to a minimum the incidence of overpulled fractures.<sup>1</sup> It is also logical to expect a greater number of such cases despite the utmost caution in a clinic where anatomical reposition and the restoration of normal length are the immediate desiderata in each fresh fracture. On the other hand, there is good reason to believe from the absence of any previous report of this nature that the factor of overpull does not enter to any noticeable extent into the etiology of malunion and pseudo-arthritis as generally reported.

The treatment of an overpulled fracture would seem to be determined as much by the fracture site, the condition of the soft tissues and the individual status as by the degree and duration of the overpull. Despite the early recognition of this condition in this group of cases, only four were successfully

## OVERPULL DURING FRACTURE TREATMENT

corrected by adjustment of the traction pull. Among the others, there was either no appreciable diminution of the interspace on reduction of the weight, or bowing and slipping occurred. In the latter instance, overpull would promptly recur with the reestablishment of good alignment. In most, apposition of the fragments took place with transfer into plaster or caliper splints. It would not be indicated to venture, here, an opinion as to the advisability of operative correction as a routine. In view of the individuality of each case, there would seem to be no generally applicable corrective measure.

### CASE ABSTRACTS

CASE I.—(Hist. No. 4538.) L. C., a well-developed and nourished white male of twenty-three years, was admitted January 15, 1926, with a compounded transverse fracture in the upper third of the shaft of the right femur. Adhesive traction, thirty pounds, was immediately applied to his leg, while he was treated for shock. Portable X-ray revealed posterior displacement of the lower fragment. After six hours, exploration of the wound was necessary due to continued bleeding and a large vein was found torn, and was ligated; at this time, ice-tongs were placed in the lower end of the femur, twenty pounds weight being applied. On the eleventh day, X-ray revealed one inch overpull. On the thirty-third day, beginning callus was apparent on the röntgenogram with overpull now one-half inch. On the thirty-eighth day, ice-tongs were removed and skin traction applied. On the forty-third day, X-ray showed anterior angulation and the skin traction was increased to fifteen pounds, which corrected this. On the sixty-second day, all traction was removed and the extremity placed in a caliper splint. He was discharged on the one hundred and second day after the injury, with clinical union at the fracture site. At four months, an X-ray showed the fracture line still to be visible despite good callus formation. Union was solid at 185 days. Follow-up at eighteen months revealed a perfect functional result with normal weight-bearing and joint motion.

CASE II.—(Hist. No. 17796.) S. G., a well-developed, previously healthy white male of twenty-five years, was admitted January 7, 1932, with a transverse fracture in the lower third of the shaft of his right femur. He had been struck by the crank handle of an elevator, ten minutes before. X-ray in emergency traction showed good position. Ice-tongs were placed in the lower end of the femur with twenty-five pounds traction weight. Twenty-four hours later, X-ray revealed one-quarter inch overpull with excellent alignment; weight was reduced to twenty pounds. On the fourth day, this was further decreased to fifteen pounds. Check-up X-ray showed the fragments approximated in good alignment. However, on the twentieth day, overpull was again manifest on the röntgenogram, in addition to a lateral displacement of the distal fragment. This was manipulated under general anaesthesia with correction of the alignment, but overpull persisted. The weight was reduced to ten pounds on the twenty-third day. Slight callus was visible at thirty-nine days and on the sixty-eighth day, union appeared firm, the tongs were removed and skin traction substituted. On the ninety-sixth day, it was evident that there was no increase in callus over that visible on X-ray one month previous. Motion at the fracture site was found at the one hundred and sixth day; the fracture line was very evident on X-ray. On the one hundred and eleventh day, the fracture site was drilled to stimulate callus formation; skin traction was then re-applied. On the one hundred and thirty-first day, union was firm, traction was removed and the patient was allowed up in a caliper splint. He was discharged on the one hundred and sixty-second day. The fracture line was still visible on X-ray at 175 days. Union was solid at 270 days.

CASE III.—(Hist. No. 15517.) H. S., a well-developed and nourished white male of twenty-four years, was admitted February 4, 1931, forty-eight hours after being injured when his sled collided with a tree. X-ray revealed a transverse fracture in the



# LESTER BLUM

middle third of the shaft of his right femur with one-half inch over-riding and posterior displacement of the distal fragment. Skin traction of twenty-five pounds was first applied for eighteen hours and then, ice-tongs with thirty-five pounds for one hour and twenty-five pounds for twenty-four hours was used. Check-up X-ray revealed some persisting posterior displacement. Because of the possibility of overpull, the weight was reduced to fifteen pounds. Despite this precaution, X-ray on the fourth day after skeletal traction was instituted, showed a definite overpull of one-quarter inch with the usual good alignment. This was corrected so that by the twenty-first day, only slight overpull was present. By the forty-third day, callus was visible at the fracture site and, on the forty-eighth day, the tongs were removed and skin traction applied, fifteen pounds and ten pounds to thigh and leg respectively. X-ray on forty-ninth and fifty-ninth days revealed no change. On the seventy-seventh day, more callus was visible, union was firm and traction removed; the extremity was placed in a caliper splint. Discharged on the eighty-fifth day. Union was solid at 230 days, the caliper splint was discarded at ten months. A röntgenogram revealed bony union with complete obliteration of the fracture line at 269 days.

CASE IV.—(Hist. No. 20288.) S. F., a previously healthy white male of thirty-nine years, was admitted December 6, 1932 shortly after being struck by a truck. X-ray in emergency traction showed a transverse fracture in the lower third of the shaft of the right femur, with the fragments in good alignment, slightly over-riding. Russell traction, seven pounds for several hours, and then increased to ten pounds, was applied. X-ray after twenty-four hours revealed some posterior tilting of the lower fragment; the weight was increased to twelve pounds. X-ray at forty-eight hours showed no change and therefore manipulation under general anæsthesia was done, Russell traction twelve pounds being then restored. The patient was more comfortable thereafter. On the sixth day, X-ray revealed beginning overpull and so weight was reduced to ten pounds. On the seventh day, the overpull was increased and so the weight was decreased to six pounds. There was no change in Röntgen appearance or in treatment until the fifty-first day, when weight was further reduced to four pounds. On the ninety-ninth day, union appeared firm, Russell traction discontinued and light skin traction in Thomas splint with Pierson extension substituted. On the one hundred and thirteenth day, X-ray showed complete posterior slipping of the distal fragment indicating that union had never taken place. Open operation was performed on the one hundred and sixteenth day, revealing fragments connected by soft, fibrous tissue. A Lane plating was done. On the one hundred and sixty-second day, there was definite bone condensation at the fracture site. He was discharged in a caliper splint at 270 days. At one year and one month, there was solid union with full weight-bearing.

CASE V.—(Hist. No. 13864.) A. D., a well-developed and nourished white male of twenty-eight years, was admitted May 23, 1930, shortly after being knocked down by a taxi. He had sustained a transverse fracture in the middle third of the shaft of the left femur. Skin traction for twenty-four hours was applied. X-ray then revealed some medial bowing with posterior displacement of the distal fragment, and so manipulation under spinal anæsthesia was done and tongs inserted—thirty-five pounds. After forty-eight hours, X-ray showed restoration of length with some lateral displacement of the lower fragment. On the third day, the weight was reduced to twenty pounds, and on the sixth day to fifteen pounds. After seven days of skeletal traction, X-ray revealed a marked overpull (almost one-half inch) with good alignment, weight being then reduced to twelve pounds. On the fourteenth day, there was no change on X-ray, but the following day, despite the overpull, the weight was increased to fifteen pounds to relieve the patient's pain. On the twenty-second day, with no change in the röntgenogram, the pull was reduced to ten pounds. On the thirty-first day, all traction weight was removed, only suspension being maintained. On the thirty-eighth day, there was marked medial bowing on X-ray with over-riding and posterior displacement of the distal fragment. There was manipulation done under the fluoroscope and ten pounds weight re-applied.

## OVERPULL DURING FRACTURE TREATMENT

On the forty-sixth day, overpull was again manifest with the fragments three-eighths of an inch apart. The weight was reduced one pound per day down to five pounds. On the sixty-fifth day, tongs were removed and skin traction used. At one hundred and sixteen days a spica was applied and patient allowed up with crutches. At one hundred and sixty-two days, he was walking with a caliper splint and crutches. At 174 days, no callus was visible on X-ray, but union was firm at seven months, and solid at 294 days. Joint function was normal.

CASE VI.—(Hist. No. 13986.) B. L., a well-preserved white male of fifty years, was admitted June 10, 1930 shortly after falling while pushing a hand truck. X-ray in emergency traction revealed an oblique fracture in the middle third of the shaft of the left femur. There was fair alignment with some over-riding. Ice-tongs—thirty-five pounds traction—was immediately instituted. After eighteen hours, X-ray showed overpull with some anterior bowing; the weight was reduced to fifteen pounds. At seventy-two hours, there was no change on X-ray, the patient was comfortable and weight was reduced to twelve pounds. On the thirteenth day, overpull was not so marked, but a lateral angulation was now visible. Callus was evident on X-ray at the thirty-first day; this was increased by the forty-third day. On the sixty-sixth day, the tongs were removed because of infection about them, despite the lack of clinical union; skin traction was substituted. On the seventy-third day, union appeared firm and all traction was removed. On the ninety-eighth day, there seemed to be some lateral and anterior bowing but he was discharged at 101 days. At ten months, he was operated on at another hospital because of angulation and a spica applied. At eighteen months, there was a röntgenogram report of no increase in callus but, at a two-year follow-up, union was found to be solid.

CASE VII.—(Hist. No. 10679.) J. H., a previously healthy thirty-year-old white male, was admitted January 17, 1929, shortly after falling four stories to the street. X-ray in emergency traction showed a transverse fracture in the middle third of the shaft of the left femur, in good alignment. Due to his poor general condition (shock, fractures of os calcis, mandible and skull) the extremity was kept in adhesive traction for the first thirty hours. Ice-tongs—thirty pounds weight—were then applied. X-ray after twenty-four hours showed good position; the weight was reduced to twenty pounds. On the seventeenth day, X-ray showed overpull of one-half inch; weight was further reduced to fifteen pounds. There was no change visible on the thirty-first day. On the sixty-first day, union appeared firm, the tongs were removed and skin traction applied. On the seventy-first day, only a faint shadow of callus was apparent on X-ray. On the ninetieth day, he was allowed up with the extremity in a caliper splint. Definite callus was visible on the röntgenogram by the ninety-fourth day and on the one hundred and ninth day, he was discharged with the caliper, on crutches. At nine months, this extremity was one and one-quarter inches longer than the other but, on X-ray, the middle-half of the fracture line was still open. At one year, union was solid and he was bearing full weight on the extremity.

CASE VIII.—(Hist. No. 8368.) G. A., a well-developed and nourished white male of thirty-nine years, was admitted December 6, 1927, with a transverse fracture in the middle third of the shaft of the right femur. X-ray in emergency traction revealed good alignment with some posterior tilting of the distal fragment. The extremity was kept in skin traction for twelve hours and then ice-tongs—twenty pounds weight—were applied. After twenty-four hours of skeletal traction, X-ray showed lateral deviation of the distal fragment with slight over-riding. On the third day, the weight was increased to thirty-five pounds for four hours and then maintained at twenty pounds. X-ray on sixth day showed no change, but, on the eighth day, beginning overpull was manifest and the traction was reduced to fifteen pounds. On the fifteenth day, there was no change on the röntgenogram and the weight was further reduced to ten pounds. On the thirty-seventh day, X-ray showed no change and no callus. X-rays on the forty-sixth and sixty-second days were no different except for some early callus visible

## LESTER BLUM

on the latter date. On the sixty-sixth day, the tongs were removed and skin traction, ten pounds, substituted. On the ninety-seventh day, a bridge of ventral callus was apparent, but none in the fracture line. At 128 days, he was allowed up on crutches with the extremity in a caliper splint. X-ray on the one hundred and fiftieth day showed coaptation of the fragments, with fair callus and beginning obliteration of the fracture line. Union was firm on the two hundred and fourth day; but the fracture line was still open. At eleven months, union was solid and the splint removed. Follow-up at two years showed excellent end-result.

CASE IX.—(Hist. No. 9212.) H. H., a fifty-three-year-old white male in good general condition, was admitted May 4, 1928, twenty-five days after having been struck by an automobile. He had been treated for this length of time at another hospital with skin traction, and a body spica. X-ray on this admission showed over-riding of one inch, at an oblique fracture in the middle third of the shaft of his left femur. Ice-tongs were inserted in the lower extremity of the femur with thirty-five pounds weight. After two hours, X-ray showed good position, and so the weight was reduced to twenty-five pounds. On the fifth day, X-ray showed overpull, and on the seventh day the weight was reduced to fifteen pounds. On the twelfth day, callus was visible along the periosteal edge. By the fortieth day, union was apparently firm with the röntgenogram showing fair callus with no change in position of the fragments. On the forty-second day, the tongs were removed and the extremity was left free on a Thomas splint suspension. Check-up X-ray showed buckling with re-fracture. Skin traction, twenty-five pounds, was applied. Twenty-four hours later, there was three-eighths of an inch overpull. The patient was now comfortable; the weight was reduced to fifteen pounds. On the sixty-third day, this overpull was no longer apparent. Union was clinically firm on the ninety-second day and all traction was removed on the ninety-eighth day. On the one hundred and third day, re-fracture occurred and a plaster spica was applied; it was removed on the one hundred and fifty-fourth day. X-ray on the one hundred and eighty-fifth day showed no callus in the medial half of the fracture line. Union was firm on the one hundred and ninety-eighth day. He was discharged in a caliper splint on the two hundred and second day. Union was solid at 320 days.

CASE X.—(Hist. No. 7186.) A. C., a well-developed and nourished white male of twenty-seven years, was admitted May 28, 1927, shortly after being struck in the right thigh by a heavy piece of machinery. X-ray in emergency traction revealed a transverse fracture in the upper third of the shaft of the right femur with the fragments in good position. Ice-tongs, thirty pounds weight, were immediately applied. Twenty-four hours later, this was reduced to twenty pounds. On the third day, X-ray showed three-eighths of an inch overpull with fair alignment. There was no change on the tenth-day pictures. By the thirty-eighth day, callus was visible and the overpull not obvious. On the forty-fourth day, the tongs were removed and skin traction substituted. This was removed on the sixtieth day. On the seventy-second day, he complained of local pain and a re-fracture was discovered on X-ray film. There was no increase in callus over that seen five weeks before and the fragments were in poor position. An open operation was done on the seventy-seventh day. A mass of soft, semi-elastic osteoid tissue was found at the fracture site. There was no soft-part intervention. A Lane plate was applied after anatomical position had been secured. The extremity was then placed in ten pound skin traction. On the one hundred and twenty-second day callus formation was evident on X-ray. At 181 days, he was up in a caliper splint. There was good callus visible, but the fracture line could still be seen. He was discharged on the two hundred and eighth day. Union was firm at 217 days, with obliteration of the fracture line on X-ray, and it was solid at 230 days.

CASE XI.—(Hist. No. 6616.) H. K., a well-developed and nourished white male of forty-four years, was admitted March 3, 1927, shortly after the wheel of a truck had passed over his left arm. There was considerable soft tissue injury about a transverse fracture in the lower third of the shaft of the left humerus. Admission X-ray showed

## OVERPULL DURING FRACTURE TREATMENT

overpull in emergency traction. There was an immediate débridement and manipulation under general anaesthesia. The arm was then put up in skin traction. After twenty-four hours, X-ray showed anterior bowing with separation of fragments, but no longer overpull. Four days later this angulation was more marked. The wound was completely healed by the sixteenth day. Open operation, two days later, revealed organizing blood-clot but no soft tissue between the fragments. A Lane plate was inserted and a plaster case applied. X-ray on the thirty-ninth day revealed good position but no callus. On the fifty-fourth day, there was considerable callus visible. End-result in this case is not known.

CASE XII.—(Hist. No. 16602.) P. Mc., a previously healthy white male of twenty-five years, admitted July 16, 1931, immediately after his arm had been struck by an automobile. After five hours of skin-traction—ten pounds (Blake board)—some anterior angulation was visible on X-ray. Twenty-four hours later, the röntgenogram showed three-eighths of an inch overpull with lateral separation of the fragments. The weight was reduced to eight pounds. On the fourth day no crepitus could be elicited and it was felt that muscle interposition had occurred. X-ray on the eleventh day showed no change in the overpull. Open operation with Lane plating was performed on the fifteenth day. A portion of the triceps muscle was found between the fragments. A plaster spica was then applied. Callus was visible on X-ray at the forty-eighth day and there was clinical union at the sixty-fifth day.

CASE XIII.—(Hist. No. 20448.) J. F., a well-developed and nourished white male of forty years, was admitted December 30, 1932, immediately after his arm had been caught in a photoengraving machine. He suffered a compounded transverse fracture through the upper third of the shaft of the left humerus. There was also injury to the brachial plexus and a brachial artery thrombosis. Admission X-ray revealed overpull of one inch in emergency traction. An immediate débridement was done, and a Kirschner wire, two pounds weight, placed through the olecranon. Check-up X-ray revealed less overpull, and some angulation. On the fourth day the radial pulse was still absent and a dry gangrene of the fingers was appearing. On the tenth day, an amputation through the proximal third of the forearm was performed. X-ray on the twelfth day showed no change at the fracture site. Check-up films on the twenty-sixth and thirty-sixth days presented the same appearance; there was no callus to be seen. In view of the poor prognosis for bony union, made worse by the trophic disturbance of the soft tissues attendant on the brachial plexus neuritis and brachial artery thrombosis, an amputation through the fracture site was decided upon and performed. The patient was discharged at fifty-one days.

CASE XIV.—(Hist. No. 7028.) J. M., a previously healthy white male of thirty-four years, was admitted May 4, 1927, shortly after slipping on the sidewalk, so injuring his right leg. X-ray in emergency traction revealed oblique fractures in the lower third of the shafts of the right tibia and fibula, in good position. Plaster splints were immediately applied. Check-up X-ray after twenty-four hours revealed definite slipping. Tongs were inserted in the malleoli, twenty pounds weight being used for twenty-four hours and then fifteen pounds. After forty-eight hours of traction, X-ray showed overpull of one-quarter inch with good alignment. On the seventh day, a Steinman pin through the os calcis was substituted for the tongs, which were slipping. Röntgenogram on the twelfth day showed no change. The weight was lowered to ten pounds on the fifteenth day. There was no change on film of the thirty-fourth day. The pin was removed on the forty-third day, and plaster splints applied. On check-up X-ray, the interspace had disappeared. On the sixty-third day, slight callus was visible, but false motion was still present. At eight-four days, there was still abnormal mobility. X-ray at 164 days showed abundant callus with obliteration of the fracture line; union was solid.

CASE XV.—(Hist. No. 6398.) F. K., a well-developed and nourished white male of twenty-seven years, was admitted January 28, 1927, after falling twelve feet to the street. He had sustained compounded oblique fractures through the middle third of the



shafts of the left tibia and fibula. The admission X-ray in emergency traction showed some over-riding and anterior displacement of the distal fragment. Immediate débridement was performed, a small bone chip removed, and the wound sutured. Tongs were placed in the malleoli. X-ray on the third day showed good position. On the sixth day, overpull of one-quarter inch was evident. The wound was clean and healing. By the twenty-first day, only five pounds traction was being used. On the twenty-fourth day röntgenogram callus was first visible and the overpull was corrected at the price of some dishing. For this reason, the traction weight was increased to eight pounds on the twenty-ninth day. No change on thirty-eighth-day film. On the fifty-seventh day, callus was increasing, and the fragments were in good position. Traction was removed on the sixty-seventh day. Mobility at the fracture site was still evident at seventy-eight days. Union was solid at 149 days.

CASE XVI.—(Hist. No. 11728.) P. S., a well-developed and nourished white male of forty years, was admitted June 22, 1929, with oblique fractures in the lower third of the shafts of the left tibia and fibula. Admission X-ray in emergency traction revealed good alignment with slight over-riding. A Steinman pin was immediately placed through the os calcis with eight pounds balanced traction. An X-ray, forty-eight hours later, showed good position of the fragments. On the seventeenth day, overpull of three-eighths of an inch was evident on the films; the weight was reduced to seven pounds. On the thirty-second day, callus was visible, but there was no other change and the weight was reduced to five pounds. On the forty-eighth day there was some increase in callus seen on the röntgenogram. At fifty-five days, the extremity was removed from traction and plaster splints were applied. Union was firm at fifty-nine days. At four months, there was excellent callus on X-ray, but the centre of the fracture line was still open.

CASE XVII.—(Hist. No. 12292.) C. E., a well-developed and nourished white male of forty-seven years, was admitted September 21, 1929, shortly after a heavy beam had fallen on his left leg. He sustained compound transverse fractures in the lower third of the shafts of the left tibia and fibula. A Steinman pin was placed through the os calcis with eighteen pounds traction weight. After twenty-four hours X-ray showed some anterior angulation with good alignment. On the seventeenth day overpull of three-eighths of an inch was visible on röntgenogram and the weight was reduced to thirteen pounds. There was no change on the twenty-second day. On the thirty-fifth day, the weight was only two pounds due to gradual decreases and on the thirty-eighth day overpull was no longer apparent. At sixty days the röntgenogram appearance was good, but there was no callus and no union. A peri-arterial sympathectomy was done on the sixty-fourth day. At ninety days he was allowed out of traction, and the extremity was placed in plaster splints. Slight callus was visible on the röntgenograms of the eighty-eighth day, but union was not yet firm. He was discharged on the ninety-second day. There was no follow-up information.

CASE XVIII.—(Hist. No. 12181.) R. H., a chronically sick (hypertension, arteriosclerosis, chronic myocarditis) white male of fifty-two years, was admitted September 4, 1929, shortly after his right leg had been run over by the wheel of a truck. Admission X-ray in emergency traction revealed compounded comminuted fractures in the middle third of the shafts of the right tibia and fibula. A Steinman pin was immediately placed through the os calcis. X-ray, twenty-four hours later, revealed slight overpull. By the ninth day the weight had been reduced to ten pounds. On the seventeenth day X-ray showed good alignment, but with an increase in the degree of overpull. On the twenty-fourth day the traction weight was reduced to eight pounds. There was no change on check-up röntgenogram. On the forty-seventh and sixty-fifth days the X-ray films revealed some increase in overpull. Traction was removed and plaster splints applied on the eighty-second day. There was neither visible callus, nor firm union by the ninety-ninth day. The patient was then transferred to a chronic hospital.

CASE XIX.—(Hist. No. 9524.) J. C., a well-developed and nourished white male of



## OVERPULL DURING FRACTURE TREATMENT

forty-seven years, was admitted June 23, 1928, shortly after being kicked in the right shin by a horse. Admission X-ray in emergency traction revealed transverse fractures in the middle third of the shafts of the right tibia and fibula; they were compounded. The wound was débrided, left open and a Steinman pin was placed through the os calcis with twenty-five pounds traction weight. After forty-eight hours X-ray showed one-quarter inch overpull with good alignment; the weight was reduced to fifteen pounds. By the forty-fifth day, the overpull had increased and the weight was further diminished to 5 pounds. The pin was removed on the sixty-first day and plaster splints were applied. A check-up X-ray showed approximation of the fragments. On the ninety-sixth day, some callus was visible, but by the 156th day, false motion was still present. Union was firm at 230 days and solid at ten months.

CASE XX.—(Hist. No. 11063.) M. S., a previously healthy white male of thirty-eight years, was admitted March 18, 1929, with transverse comminuted fractures in the middle third of the shafts of the left tibia and fibula. On admission, due to shock, the extremity was left in the emergency traction for eight hours. X-ray then showed three-eighths of an inch overpull. A Steinman pin was placed through the os calcis and ten pounds traction weight used. By the end of forty-eight hours, the overpull had been corrected. X-rays on the sixteenth and twenty-third days showed no change. On the twenty-eighth day a little overpull was again manifest. By the fifty-second day good callus was visible at the fracture site. The fracture line was partially obliterated at the eightieth day and the extremity was removed from traction on the eighty-eighth day. He was discharged at 120 days. There was good union with much callus visible at 185 days.

CASE XXI.—(Hist. No. 11714.) F. M., a well-developed and nourished male of thirty-eight years, was admitted June 21, 1929, shortly after a wagon wheel had passed over his right leg. He had sustained compounded fractures of the right tibia and fibula. Admission X-ray in emergency traction revealed oblique fractures in the lower third of the shafts of both leg bones with some over-riding present. A Steinman pin was immediately placed through the os calcis with fifteen pounds traction weight. After twenty-four hours, overpull was visible on röntgenogram with some angulation. This was still apparent on the eighteenth day and two days later the weight was reduced to twelve pounds. There was no change on the thirty-third day, and so the weight was further diminished to six pounds. The forty-second day film showed even slight increase in overpull; no callus was visible. On the forty-ninth day, a peri-articular sympathectomy was done. On the seventy-fourth day, despite lack of firm union and absence of visible callus, all traction was removed and the leg placed in a modified Delbet splint. Following this, the fragments were apposed in good alignment. Callus was first seen at 145 days. At one year and nine months, the fracture line was still partly visible and union was not yet firm.

CASE XXII.—(Hist. No. 10145.) J. A., a chronically ill (chronic cardiac valvular disease) male of twenty-five years, was admitted October 15, 1928, shortly after a load of sheet iron had fallen on his right leg. X-ray on admission in emergency traction revealed oblique fractures in the middle third of the shafts of the right tibia and fibula in good position; they were compounded. Plaster splints were applied. Check-up films on the second and fifth days revealed good alignment, but by the twelfth day slipping had occurred. On the fifteenth day, ice-tongs were inserted into the malleoli, twenty-five pounds traction weight being used. The next day excellent alignment was apparent on the films. On the twenty-first day (sixth day of traction) overpull of one-quarter inch was manifest. The tongs were slipping, and therefore removed; skin traction, fifteen pounds weight, was substituted. Three days later X-ray showed some slipping and on the twenty-ninth day (eighth day of skin traction) there was definite dishing with lateral angulation. On the thirty-first day a Steinman pin was inserted into the os calcis, fifteen pounds traction weight being applied. After twenty-four hours overpull of one-quarter inch was visible on the röntgenogram; the weight was reduced to ten pounds. On the

## LESTER BLUM

fiftieth day, there was no change and no visible callus. The weight was reduced to five pounds on the sixty-third day. Callus was first seen at the ninety-second day, at which time false point motion was still evident. The extremity was removed from traction on the ninety-eighth day and plaster splints were applied. He was discharged on the one hundred and fifth day. Union was clinically firm at six months and solid at thirteen months.

CASE XXIII.—(Hist. No. 7375.) S. T., a previously healthy white male of forty years, was admitted June 24, 1927, just after a truck wheel had passed over his left leg. He sustained oblique fractures through the lower third of the shafts of the left tibia and fibula. On admission X-ray in emergency traction the fragments were in good position. A Steinman pin was placed in the os calcis and twelve pounds traction weight employed. After twenty-four hours overpull was evident and persisted after adjustment of the weight; it was still visible on the fifth day röntgenogram. The weight was then reduced to ten pounds. On the eleventh day there was no change, and on the thirty-fourth day the overpull was still present. The pin was removed on the forty-first day and skin traction applied. There was no callus on the sixty-third day film, but union was firm by the seventy-fourth day. He was then allowed up with crutches and discharged.

CONCLUSIONS.—A clinical review of twenty-three cases of overpull in fractures of the shafts of long bones reveals this condition to be a serious one by reason of an associated marked delay in healing, a higher incidence of necessary operative procedures, and an increased time of hospitalization.

It usually occurs in the first few hours and days following the institution of effective traction and is, as a rule, not successfully corrected by simple diminution of the tractive force.

The prevention of overpull is of more efficacy in avoiding the untoward sequelæ than is its treatment. This can be accomplished only by more thorough analysis of all the factors involved in each individual patient before ordering the type and amount of traction to be applied.

In view of the widespread employment of the traction-suspension method in the treatment of fractures the gravity of this complication renders it worthy of serious consideration.

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ARTHROTOMY OF THE KNEE-JOINT  
A STATISTICAL STUDY OF TWO HUNDRED FIFTY CASES  
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FROM THE HOSPITAL FOR JOINT DISEASES

MOST of those at present engaged in the practice of orthopædic surgery can still recall the timidity with which even accomplished surgeons approached the opening of the knee-joint. This fear has been largely overcome in the minds of orthopædists, but to a large number of surgeons, a great majority of general practitioners, and practically all of the lay public, the mere suggestion of surgical intervention on the knee still conjures up the spectre of dire consequences. So prevalent is this feeling that even simple aspiration of the joint is still viewed with alarm and frequently combated with vigor. In great part this attitude is justifiably based on the unfortunate results of joint surgery in its early days. In equal measure it is fostered by the over-cautious writings of some of our most eminent surgeons. None can deny that no amount of *useful* precaution is superfluous in the care of the patient. Nevertheless, if our surgical ritual, *e.g.*, the insistence on the Lane technic, is such as to intensify rather than mollify natural fears, and to dissuade both medical and lay public from those very procedures, for the success of which the precautions were designed, it would appear desirable to pause with the view of determining which of these measures is useful and which is superfluous.

The writers have felt that many current surgical practices have become mere fetiches and that a careful survey of the facts would demonstrate that no greater morbidity existed after arthrotomy than after other types of operations, and that no greater care or fear need be invoked in the contemplation of such procedures. With this object in view, we have undertaken a review of 250 consecutive arthrotomies of the knee performed at the Hospital for Joint Diseases, during the period from 1920 to July, 1932. The series consists mainly of cases which may be grouped under the generic term of internal derangements of the knee, because it is particularly in this type of case that the popular misconception as to the results of arthrotomy exerts its greatest and most harmful influence. The cases were operated upon by the staffs of the several orthopædic and surgical services of the hospital, as well as by the surgeons of the courtesy staff, and the series consequently represents a fairly accurate cross-section of surgery as practised upon the knee-joint.

The study has proven interesting in that it has permitted of a comparison of our results with those of others who have used the ultra-strict Lane technic. To the best of our knowledge, true Lane technic has never been used at our hospital. Some of our surgeons have used what they call a "no-touch"

technic, which resembles Lane's only in the sense that not even the gloved finger is introduced into the wound. Others have employed what may be called "ordinary surgical" technic, in which no dismay is displayed at carefully examining the joint with the finger, should necessity demand. The conclusions which we have been able to adduce from the data here collected should not be considered as in any sense a criticism of any other surgeon's work. At best, percentages should be accepted as indicating general trends. In this sense, we believe that figures which we shall present have justified the attitude expressed earlier in this paper.

Of the total of 250 cases, thirteen or 5.2 per cent. were described as "infected." This term was applied to all cases in which complete primary union had not occurred at the first dressing. It was further defined by subdividing the cases into "superficial infections"—those in which the skin or subcutaneous tissues only were involved—and "deep infections"—in which the joint proper was involved in the inflammatory process. Of these there were:

TABLE I  
*Wound Infections*

Superficial infections.....	9 or 3.6 per cent.
Deep infections.....	4 or 1.6 per cent.
Total.....	13 or 5.2 per cent.

Though we did not consider this an alarming post-operative morbidity, they were still sufficiently greater than those reported by Moorhead (*ANNALS OF SURGERY*, vol. 96, p. 17, 1932), to warrant closer investigation.

In view of the fact that all of his cases were operated upon with strict attention to the details of the Lane technic, it was natural to inquire whether the technic employed bore any definite relationship to the percentage of infection. The following was noted:

TABLE II  
*Relation of Technic to Infection*

Technic	No. of Cases	No. of Infections	Per Cent. of Group	Per Cent. of Total 250 Cases
Ordinary surgical...	158	Superficial, 6	3.8%	4%
		Deep, 4	2.5%	
Lane (Moorhead)...	188	Superficial, 4	2.5%	2.1%
No-touch.....	92	Superficial, 3	3.3%	1.2%

At first sight, these figures appeared to be quite clear cut and to the point conclusively to the superiority of the two latter procedures over the first. On the other hand, the superiority of the Lane over the no-touch technic seemed to be somewhat less striking than might have been expected. This difference could be still further minimized by recalling that Moorhead's figures presented presumably the work of an individual surgeon with tremendous experience, whereas our figures presented the work of a relatively large number of surgeons with varying experience in this particular field.

# ARTHROTOMY OF THE KNEE-JOINT

When Table II was re-studied in this light, the drawing of entirely different conclusions seemed necessary.

For this purpose, all of the surgeons who operated upon the cases in this series were divided into two categories: (1) those who had operated upon twenty or more cases, and (2) all others who had not. In the first group there were five surgeons: A-E, whose results have been tabulated individually.

TABLE III  
*Relation of Individual's Technic to Infection*

Surgeon	Technic No. of Cases	No. of Infections	Per Cent. of Group
A.....	Lane.....	—	—
	No-touch..... 27	0	0%
	Ordinary..... 20	0	—
B.....	Lane.....	—	—
	No-touch.....	—	—
	Ordinary..... 31	1 (deep)*	3.2%
C.....	Lane.....	—	—
	No-touch..... 24	0	0%
	Ordinary.....	—	—
D.....	Lane.....	—	—
	No-touch..... 20	1 (superficial)	5.0%
	Ordinary.....	—	—
E.....	Lane.....	—	—
	No-touch.....	—	—
	Ordinary..... 20	0	0%
F..... (All others)	Lane.....	—	—
	No-touch..... 21	2 (superficial)	9.5%
	Ordinary..... 87	3 (deep) 6 (superficial)	9.9%

\*This case developed an infection from a foreign particle which fell into the wound from a moving overhead light. Though it is included in the series, it is not felt that in all strictness it connotes a criticism of the technic.

It will be observed that surgeons A-E operated upon a total of 142 cases, with two or 1.4 per cent. of infections, which compares quite favorably with the 2.1 per cent. noted under the Lane technic. It is further to be noted that of the 142 cases, seventy-one were operated under no-touch precautions and an equal number by ordinary surgical technic. In either instance only one infection was noted. In the case of surgeon A, who operated upon twenty-seven cases by the no-touch method, and twenty cases by the ordinary surgical method, not a single infection was recorded. Even in Group F, where eleven infections (10.2 per cent.) were noted, the morbidity in the ordinary surgical group was but slightly greater than in the no-touch group. From the study of this table it seemed that so far from justifying faith in the Lane technic, *per se*, our figures demonstrated that reliance on it was illusory and the firm adherence to its ceremonials superfluous. It would appear then as a conclusion that a certain percentage of infection not greater than that seen in other types of operations is to be expected. It would further appear that



# MILCH AND RAISMAN

experience is of the utmost significance and that, in general, the morbidity will vary inversely with the surgeon's experience. On the other hand, it would seem that the morbidity will not be influenced by the technic employed, provided the operator uses his "surgical conscience" and the usual amount of aseptic care during the course of the operation.\*

Almost exactly the same conclusion must be drawn as to the value of duplicated pre-operative preparations of the skin. Most surgeons do not hesitate to open the abdominal or even the cranial cavity without indulging in any chimerical hope of "sterilizing" the skin. Yet, when these very surgeons approach the knee-joint, they become so obsessed with the dread of infection that a new sort of ritual, consisting of repeated washings, paintings and dressings, must needs be invoked. To our minds, these devotions are as superfluous in the pre-operative preparation of the patient as is the Lane technic in the actual conduct of the operation. The data we have been able to gather on this point have been taken necessarily from order sheets and nurses' notes and while we believe them reliable, should be accepted with that reservation.

TABLE IV  
*Relation of "Preps" to Infection*

No. of Preps	No. of Cases	No. of Infections		Per Cent. of Group
		Superficial	Deep	
I.....	168	4	2	3.6%
More than I.....	78	4	2	7.7%
Unknown.....	4	1		25%

Here, again, we observed the same incongruity of results, if the fundamental thesis that repeated preparation is essential to decreased morbidity be accepted. Though the number of cases of infection in each group was the same, it will be noted that in the second class the percentage was estimated on somewhat less than half the number of cases recorded in the first group. Unless the additional scrubbing and cleansing of the skin may be considered to have irritated and lowered its resistance to bacteria present in the pores, we were at a loss to explain this relative increase of infections in the very group in which the opposite would have been expected. Whatever the cause may have been, the conclusion was apparent that an increased degree of safety was not insured by multiplication of the pre-operative manipulations. As a result, we have made it a practice not to indulge in more than

\* Since preparing this paper for publication we have noted with great interest the statement of a somewhat similar sentiment by G. A. Hendon, before the Southern Surgical Association, on December 13, 1932, which was reported in abstract in the Journal of the A.M.A. February 18, 1933, page 525. In discussing the open treatment of fractures of the shaft of the femur, Hendon observed: "The danger of infection can be dismissed as a serious obstacle, because the commonly accepted standards of modern asepsis render infection remote, and should it occur, the process of bony union is not gravely interfered with. The non-touch technic is not considered essential and was not used in our work."

## ARTHROTOMY OF THE KNEE-JOINT

one skin preparation and seldom of greater duration than twelve hours before operation. Whenever the occasion has presented itself, we have availed ourselves of the opportunity of testing the truth of this belief by sending the patient to the operating room as soon after admission as was possible. The number of cases thus treated is not yet sufficient to permit of statistical analysis, but, from personal observation, we have gained the impression that these patients have had quite as uneventful a convalescence as those in whom the more orthodox preparation had been employed.

With these findings as to the relationship of infection to the preparation of the skin and the surgical technic as a general background, it was decided to pursue the subject further in an effort to elucidate the auxiliary factors, if any, which might be effective in the determination of infection. When it was recalled that practically all of these arthrotomies were performed under a tourniquet, it appeared reasonable to inquire whether the duration of the operation affected the incidence of infection. This was found to be true in a very intimate sense, as the following table shows.

TABLE V  
*Relation of Duration of Operation to Infection*

Duration of Operation	No. of Cases	Infection		Per Cent. of Group
		Superficial	Deep	
30 minutes or less.....	58	0	0	0%
31 to 40 minutes, inclusive.	55	1	1	3.7%
Over 40 minutes.....	109	7	3	9.1%
Unknown.....	28	1		3.6%

Thirty minutes was selected as an arbitrary standard of reference, because it was considered as an average time for excision of an injured semilunar cartilage, the operation which was most frequently performed in this series. It was at once almost platitudinously obvious that the longer the duration of the operation, the greater became the likelihood of infection. This tendency was attributed partly to the prolongation of the ischæmia, partly to the complexity of the operative procedure and partly to the increase in the length of the incision, with consequent cooling and drying of the tissues. The confirmation of this belief was found in the tables herewith appended.

TABLE VI  
*Relation of Operative Procedure to Infection*

Nature of Operation	No. of Cases	Infection		Per Cent. of Group
		Superficial	Deep	
Simple arthrotomy.....	8	0	0	0%
Removal of cartilage.....	161	2	3	3.1%
Removal of joint mice.....	25	1	1	4%
Repair of fractured patella.	16	1	0	6.3%
Synovectomy.....	26	3	0	11.5%
Complicated operations, crucial ligaments, etc.....	14	2	0	14.3%

## MILCH AND RAISMAN

TABLE VII  
*Relation of Length of Incision to Infection*

Length of Incision	No. of Cases	Infection		Per Cent. of Group
		Superficial	Deep	
Under 4 inches.....	103	1	0	1%
4 inches or more.....	89	5	3	8.9%
Unknown.....	58	3	1	6.9%

In compiling Table VII, we were confronted with a number of charts in which the exact length of incision was not given and we attempted to overcome this difficulty by contrasting, in regard to the morbidity, the transverse, longitudinal and split-patellar incisions. Under "transverse" were included the Jones and Fischer incisions, and under "longitudinal" the medial and lateral parapatellar, the vertical, oblique, bilateral and horseshoe incisions.

TABLE VIII  
*Relation of Type of Incision to Infection*

Type of Incision	No. of Cases	Infection		Per Cent. of Group
		Superficial	Deep	
Split-patellar.....	13	0	0	0%
Transverse.....	86	1	0	1.2%
Longitudinal.....	127	7	4	8.7%
Unknown.....	24	1	0	4.2%

The apparent superiority of the transverse incision to all others is at once seen. However, it must not be forgotten that the more extensive procedures, with the greater liability to infection, were necessarily performed under the longer incisions. It is interesting to note, in passing, that of the transverse wounds, thirty-two or 37.2 per cent., of the longitudinal wounds fifteen or 11.8 per cent. were closed in thirty minutes or less. This is quite in consonance with the conclusions previously reached as to the relationship between the length of the incision, the duration of the operation and the development of post-operative infection.

When the analysis of Table VIII was applied specifically to the 161 cases of menisectomy noted in Table VI, the same superiority of the transverse over the longitudinal incision was noted.

TABLE IX  
*Relation of Type of Incision for Menisectomy to Infection*

Type of Incision	No. of Cases	Infection		Per Cent. of Group
		Superficial	Deep	
Split-patellar.....	3	0	0	0%
Transverse.....	76	1	0	1.3%
Longitudinal.....	69	1	3	5.8%
Unknown.....	13	0	0	0%

Nevertheless, the whole tale about the comparative values of these types of incisions has not been told by mere reference to the incidence of infection. The long incision has certain advantages over the shorter incision. It greatly facilitates removal of the posterior horn of the cartilage and affords ready access to every part of the joint. This "exploratory" value of the long incision must be given due emphasis in view of the fact that many cases must still be submitted to operation with the indefinite diagnosis of "internal

## ARTHROTOMY OF THE KNEE-JOINT

derangement." On the other hand, in addition to its greater liability to infection, the long incision has certain very definite disadvantages. It tends to prolong convalescence and to delay the return of the patient to normal activity. We have seen many cases in which, despite the institution of early motion, disability has persisted unduly long. In some this has been due to the development of synovial adhesions, especially in the quadriceps bursa. In others, it has been due to weakness of the quadriceps muscle. This paresis is, in all probability, to be associated partly with the atrophy commonly seen in knee-joint injuries, even where no operation has been undertaken, and partly with delay in healing of the vastus to the rectus femoris tendon. In several cases we have felt a distinct hiatus over this portion of the incision and in one case, operated upon at another hospital, we have noted complete non-union with external dislocation of the patella, a disability more distressing to the patient than the cartilage injury for which she was originally operated.

As a result of these considerations, we have made it a practice to use the short, transverse incision when, in our minds, there has been no question of the diagnosis of a cartilage injury alone. Where there has been doubt, or where the existence of several lesions has been suspected, and where, consequently, the exploratory nature of the operation had to be considered, we have attempted to combine the advantages of the short with those of the longitudinal incisions. In such cases we have made a short, parapatellar incision, exercising care that the upper end of the incision should not extend beyond the lowermost fibres of the vastus muscle. This approach is ample for the exploration of the homo-lateral half of the joint, and, with the additional excision of the post-patellar fat pad, affords a fairly adequate view of the contra-lateral portion of the joint. Should conditions warrant it, the incision may be readily extended into the usual parapatellar approach.

At the outset of this study we had hoped to be able to present some data on the relationship of these various elements in our surgical procedure to the ultimate prognosis. Unfortunately, this was rendered impossible by the paucity of the replies received. To allay the fears of those who still regard the opening of the knee-joint as an almost certain invitation to "stiffness" of the joint, it may be noted that of this entire series only one case developed an ankylosis of the joint. Even here this outcome might have been avoided, if rubber tube draining into the joint had not been used.

*Conclusion.*—A series of 250 cases has been statistically analyzed and it has been shown that, within the experience of the individual surgeon:

- (1) Repeated skin preparations were unnecessary and might be harmful.
- (2) The Lane technic showed no such great preponderance over the other procedures as to render it a *sine qua non* of arthrotomy.
- (3) The percentage of infection in arthrotomy of the knee was not greater than that seen in the usual surgical procedure.
- (4) The percentage of infection apparently varied with the complexity and duration of the operation and with the size of the incision.
- (5) "Stiffness" was an extremely infrequent complication, even after complication intra-articular operations.

## RECURRENT SUBLUXATION OF THE ANKLE-JOINT

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THE external lateral ligament of the ankle-joint consists of three separate bands. The anterior fasciculus is attached to the front of the outer surface of the external malleolus and passes forwards to the astragalus just behind the neck of the bone. The middle fasciculus passes downwards and slightly backwards from the tip of the malleolus to the external surface of the os calcis beneath the peroneal tendons. The posterior fasciculus springs from the fossa on the deep surface of the malleolus and passes inwards to the tubercle on the posterior extremity of the astragalus.

The common sprain of the ankle-joint occurs when the ankle is plantar flexed; forced inversion then causes an injury to the anterior fasciculus. Even if this fails to unite, no instability of the ankle-joints results. A not uncommon result of such a sprain is the formation of adhesions in front of the external malleolus with tenderness and swelling at this spot and a loss of inversion of the foot—the condition commonly described as a chronic sprain of the ankle.

If, however, the foot is forcibly inverted when it is at a right angle to the leg, the middle fasciculus of the external ligament may rupture or may be torn from its fibular attachment. Probably when this occurs the anterior fasciculus ruptures at the same time. The rupture of these two ligaments allows the astragalus to tilt in its mortise between the malleoli, so that a subluxation of the ankle occurs.

The ligaments which reinforce the capsules of joints may be divided into two classes: (1) Those which are incorporated in the capsule and form simply thickened portions of this structure, and (2) those which form isolated rounded bands which are anatomically separate from the capsule. The middle fasciculus of the external lateral ligament falls into the second group. These isolated ligaments when completely ruptured do not tend to unite unless sutured surgically and consequently when they are ruptured, instability of the joint results. This is well seen in contrasting rupture of the internal and external lateral ligaments of the knee-joint. The internal lateral ligament is a thickened part of the capsule; when it is ruptured it unites if it is protected from strain. The external lateral ligament is a separate extracapsular band; when it is completely ruptured it fails to unite and leaves an unstable knee unless treated by operation.

When the middle fasciculus of the external lateral ligament of the ankle has been ruptured, an unstable joint results. Inversion of the foot then allows the astragalus to tilt in its socket, the ankle giving way.



## RECURRENT SUBLUXATION OF ANKLE-JOINT

In this connection it may be as well to consider to what extent lateral mobility is possible in the normal ankle-joint. According to Quain:

When the joint is bent (dorsiflexed) the wide part of the astragalus is pushed back into the socket, and the external malleolus is forced outwards; whereas in extension (plantar flexion) the external malleolus follows the curve of the outer surface of the astragalus, being drawn inwards mainly by the posterior band of the external lateral ligament. In this way a certain spring is given to the articulation. In the mid-position of the joint, when the ligaments are least stretched, a limited degree of lateral motion is allowed under the influence of external force, but it is probable that such movements do not occur naturally.

Doctor Coldwell has kindly tested the mobility by taking X-rays of the ankles of members of his staff. In only one out of seven could any tilting of the astragalus be demonstrated by forced inversion of the foot. In this case, a young and supple-jointed nurse, there was only a very slight tilt on one side but on the other the astragalus could be tilted so that its external articular facet projected below the tip of the external malleolus.

In the following four cases an inversion injury of the ankle left a laterally unstable joint which was subject to recurrent sprains. It was found that the astragalus could tilt in its socket to an abnormal extent and at operation complete rupture of the anterior and middle fasciculi of the external lateral ligament was demonstrated.

CASE I.—P. T., male, aged eighteen, October 6, 1927, gave a history that six weeks before, while walking along the curb, his left foot slipped into the gutter, being turned forcibly inwards. The foot remained inverted until he pressed it down against the ground, when it came back into position with a snap. October 5, while playing tennis, he turned his foot over again and had to push it back with his hand. On examination there was laxity of the ankle-joint to an extent which allowed rotation of the astragalus. This was demonstrated by an X-ray photograph taken in forced inversion (Fig. 1) which also showed a loose fragment of bone below the lip of the external malleolus which moved downwards when the foot was inverted. There was no separate fragment of bone in this situation on the other side. As the disability continued, the operation for reconstruction of the two fasciculi of the external lateral ligament was carried out April 3, 1928. The foot was fixed in plaster for a fortnight and after this an inside steel and varus T-strap was worn for four months. The result was quite satisfactory, the ankle remaining stable and permitting all forms of exercise.

CASE II.—T. L., male, aged thirty-one, attended hospital November 12, 1928. He gave the history that he had sprained his right ankle fifteen years before, being laid up for a month. Ever since then the ankle has periodically turned over so that he fell down. He was able to get up again and walk on. The ankle swelled, but did not get discolored.

On admission to hospital, January 6, 1929, it was found that inversion of the right ankle was a little more than that of the left and an X-ray showed slight tilting of the astragalus. Reconstruction of the anterior and middle fasciculi of the external lateral joint was exposed the astragalus could be made to tilt through  $45^{\circ}$ . The foot was kept in plaster for one month.

CASE III.—Mrs. R., aged twenty-four, consulted me September 23, 1931. She gave the history that she first sprained her right ankle when at school, and that ever since the ankle had been sprained at intervals and during the past summer it had been turning over constantly. On examination there was some tenderness in front of the external

malleolus where there was a distinct hollow. The foot inverted freely, inversion was not painful and the astragalus could be felt to tilt. This tilting was clearly shown in an X-ray. The operation for reconstruction of the ligament was carried out November 5, 1931. The two fasciculi were entirely absent and there was a considerable sac of redundant synovial membrane below and in front of the external malleolus. When the joint was exposed the astragalus could be made to tilt through  $45^{\circ}$ . The foot was kept in plaster for five weeks. Seen March 7, 1932, the range of inversion was two-thirds of the normal, the foot quite strong and the astragalus could not be tilted.

CASE IV.—R. B., male, aged twenty-three, consulted me March 22, 1933. He gave

the history that in February, 1928, while playing Rugby football, he twisted his right ankle and heard a loud crack. The ankle did not recover and in September, 1928, he had a manipulation by a bonesetter. After this he was all right until June, 1932, when he twisted the ankle again in a rabbit hole; he did not get bad bruising on this occasion. In October, 1932, he had a further twist while playing golf and after this the ankle felt unsafe.

On examination it was found that inversion of the ankle was greater than on the other side and on forced inversion the external articular facet of the astragalus could be felt below the external malleolus. As the ankle had already been X-rayed and the diagnosis was evident, an X-ray in full inversion was not taken.

The reconstruction operation was carried out April 4, 1933, and both fasciculi were found completely ruptured. The ankle was kept in plaster for six weeks. Five months after operation the ankle was quite strong and stable with only slight loss of inversion.

*Diagnosis.*—The only difficulty in diagnosis is the distinction of these instances of recurrent subluxation from the much more frequent cases of chronic recurrent sprain. In the latter there is a history of recurrent



FIG. 1.—X-ray of Case I taken with the ankle fully inverted, showing tilting of the astragalus and a separated portion of bone below the external malleolus.

sprains of the ankle often with chronic swelling and pain in front of the external malleolus. There is loss of inversion of the foot and pain when this movement is forced. In recurrent subluxation there is also the history of recurrent sprain, but pain is not a marked feature and the patients complain more of instability and a feeling of insecurity. There is a hollow round the external malleolus instead of swelling, and inversion of the foot is excessive. Moreover, on inversion it may be possible to feel the external articular facet of the astragalus under the skin. The middle fasciculus of the external ligament can sometimes be felt in a thin patient and its absence in a case of

## RECURRENT SUBLUXATION OF ANKLE-JOINT

recurrent subluxation may be detected. This was possible in Case III. Finally, an X-ray taken in full inversion demonstrates the tilting of the astragalus.

*Operation.*—Evidently the rational treatment of this condition is the reconstruction of the anterior and middle fasciculi of the external lateral ligament with fascia. This was carried out in each of the cases described by the following method:

A curved incision five inches long is made along the line of the peroneus brevis tendon, starting two inches above the external malleolus. The skin is reflected a short distance up and down and the incision deepened down to the bone in front of the peroneal tendons and these tendons are displaced downwards in their sheath. The external malleolus the outer side of the os calcis and the neck of the astragalus are then exposed and cleared.

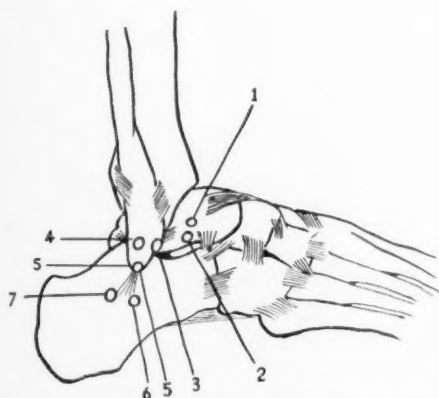


FIG. 2.—Diagram of the outer side of the ankle-joint, showing the ligaments and the drill holes made in the neck of the astragalus, the external malleolus and the os calcis. (See text.)

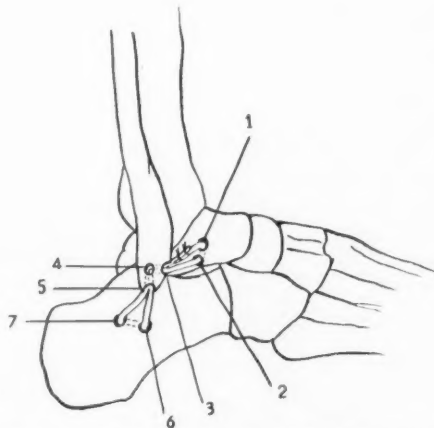


FIG. 3.—Diagram showing the method of passing and suturing the strip of fascia.

With a twist drill (one-eighth inch) a series of holes are then drilled in the external malleolus astragalus and os calcis. (Figs. 2 and 3.) 1 and 2 pass obliquely into the neck of the astragalus so as to meet at a depth of about one-half inch. 6 and 7 pass similarly into the os calcis. 3 passes horizontally backwards and 5 vertically upwards into the external malleolus and 4 is made to connect with these in the depth of the bone.

A strip of fascia lata one-half inch wide and eight inches long is taken from the outer side of the thigh and threaded through the holes as follows: In at 1, out at 2; in at 3, out at 4; in at 4, out at 5; in at 6, out at 7; in at 5, out at 4; in at 4, out at 3. The ends at 1 and 3 are then pulled up tight with the foot at a right angle and everted; they are then securely sutured together with thread.

After suture of the wound the ankle is fixed in plaster in slight eversion for six weeks, and is then treated by massage and gentle manipulations until movement and strength are restored.

## SUBCUTANEOUS RUPTURE OF THE TENDON OF THE TIBIALIS ANTICUS

By MICHAEL S. BURMAN, M.D.

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ONLY two cases of subcutaneous rupture of the tendon of the tibialis anticus have been recorded. Two further cases are here reported.

CASE I.—A. E., sixty-nine years old, came to my office April 25, 1933, because of pain in his right foot. A wheel of an automobile ran over this foot a year ago. There was no fracture and he recovered very quickly from the injury to the soft parts of the foot with no residual disability.

About two weeks before I first saw him, he felt a sharp but inconstant pain in his right foot in the general area of the insertion of the tendon of the tibialis anticus. A week after this, in trying to avoid a moving automobile, he experienced a sudden, sharp pain in the foot, as if something had snapped within it. This pain, which lasted only five to ten minutes, was definitely localized in the region of the insertion of the tibialis anticus. A dull ache, appearing at intervals, then persisted. He walked carefully without a limp but a misstep was painful. A week after this primary acute episode of pain, and a day before his visit to me, he stepped into a puddle of water heel first, as he was about to board a street car. He again felt a sudden, knife-like, piercing pain in the right foot. He limped over to the waiting street car, and, after five or ten minutes, the pain subsided. When I saw him, he complained of slight pain in the foot, most marked on side-to-side motion of the foot, of inability to dorsiflex the foot completely, and of a slight limp.

His past history was negative for any important disease. A brother died of diabetic gangrene. He himself has had sugar in the urine at times.

General examination was negative. The man was well formed and developed and looked much younger than his actual age. His blood-pressure was 114/68.

He was careful in setting down the right foot in walking and a mild limp was noted only when he walked without shoes. Slight swelling with very mild ecchymotic discoloration was present over the anterior and medial aspect of the ankle. The tendon of the tibialis anticus was neither seen nor felt in its proper place. This was made very evident on dorsiflexion and inversion of both feet. Marked tenderness was noted over the normal insertion point of the tendon and no tendon structure could be palpated there. The proximal end of the tendon could not be felt distinctly because of the swelling about the ankle, but marked tenderness over the ankle-joint, just below the upper limb of the anterior annular ligament, indicated the site of the proximal end of the tendon. Lesser tenderness was present along the course of the tendon beneath and above the anterior annular ligament and over the muscle belly proper. Dorsiflexion was possible to about 100°, about 15° less than in the normal left foot. This movement was, however, strong. Inversion and eversion were full and strong but slightly painful. All other motions of the foot were normal. The extensor hallucis longus and the extensor digitorum longus were intact. No spasm of any muscle group was present. Good pulsation was felt in the dorsalis pedis arteries of both feet.

The diagnosis was not difficult. A *spontaneous, intrathecal rupture of the tendon of the tibialis anticus* had taken place at or near its point of insertion.

The foot was strapped in inversion and dorsiflexion to compensate for the action of the missing tendon. Rest was advised. A roentgenogram showed no chip fracture at the site of insertion of the tendon nor any other bony abnormalities. Mild calcification of the vessels of the leg and foot was noted.

## RUPTURE OF TENDON OF TIBIALIS ANTICUS

Reëxamination twelve days later showed no swelling about the ankle. The patient claimed that he was able to walk as far as he wished with comfort, although he did complain of a little pain over the anterior surface of the right leg and in both calves. The proximal end of the tendon was felt as a rounded, knob-like structure, painful on palpation, just below the upper limb of the anterior, annular ligament. Pain was still present over the muscular belly and at the insertion point of the tendon. Dorsiflexion was powerful and was possible to  $95^{\circ}$ , the normal left foot dorsiflexing to  $85^{\circ}$ . Inversion, effectually accomplished by strong contraction of the tibialis posticus, was full and strong. No limp was noted but the right foot tended to go into mild valgus. Foot plates were therefore made.

July 1, 1933, he was able to walk one to two miles fairly well, although it had become more difficult than before. No limp was present. Pain was occasionally noted in both legs, more so in the left, although he did not feel that he was favoring the left side. No typical story of intermittent claudication was given. The pain was relieved by brief rest. A misstep or walking on uneven ground created a sharp but momentary pain over the tendon; on level ground he walked without pain or limp.

Examination showed that the tendon of the tibialis anticus had *not* reformed. Its proximal end was felt as a smooth, rounded, firm body placed *above* the upper limb of the anterior annular ligament, indicating a further retraction of the tendon. The distance between the proximal end of the tendon and its normal point of insertion was four and one-quarter inches, when the foot was dorsiflexed to  $90^{\circ}$ . The proximal end of the tendon and the tendon itself were moderately painful to pressure. No pain was present over the muscle belly and very little at the insertion point. All motions, including dorsiflexion and inversion, were full and strong. The foot was now in moderate valgus, whereas the left foot was in neutral position. Limp was absent.

The patient felt that his symptoms were not severe enough at any time to warrant an operative suture of the tendon. He came now under treatment for a mild sciatica which responded very readily to baking and massage. He was seen last July 15, 1933. He had then noted a sharp, continuous pain in his right foot for a day. The ankle-joint, which was very accessible to palpation because of the absence of the tendon of the tibialis anticus, was very painful anteromedially, even to moderate pressure. This was most marked at the tibial origin of the joint capsule. A diagnosis of sprain of the anterior aspect of the ankle-joint was made. This was most likely due to increased effort in dorsiflexion. The patient died suddenly two days later of a heart attack.

CASE II.—I am indebted to Dr. Leo Mayer, whose patient this man is, for the presentation of this case.

Dr. R. N., aged forty-eight (History No. 17886, Hospital for Joint Diseases, New York City), forced or kicked a heavy object with his right foot July 6, 1928. He experienced an immediate sensation of "dropping of the foot" with a definite feeling of weakness of the foot. The foot became swollen at once, mainly on the inner aspect of the ankle-joint, and remained so for several days. No pain was complained of.

Operation was done July 13, 1928. The tendon had been torn in its substance near the lower level of the anterior annular ligament. The distal stump of the tendon of the tibialis anticus was fibrillated and covered with blood-clot to about one-half inch of its insertion point. An incision which exposed the proximal part of the tendon showed an intrathecal blood-clot the size of a chestnut. The sheath was opened for one-half inch to evacuate the clot. The proximal end of the tendon was enlarged and fibrillated, and adherent to the sheath at points by blood-clot. The tendon near the torn proximal end was reddish-blue because of intratendinous hæmorrhage. The proximal stump was sewed to the distal stump intrathecally, silk sutures reënforcing the chromic catgut sutures of the Mayer-Bunnell stitch. A plaster case was applied from the toes to mid-thigh, the foot being held in  $90^{\circ}$  of dorsiflexion and the knee being slightly flexed. He was discharged a week later after an uneventful post-operative course.

The plaster was split August 3. There was still slight tenderness over the tendon



but it showed active power. Two weeks later, the strength of the tendon was estimated at 50 per cent. of the normal and dorsiflexion was good. Simple adhesive strapping now sufficed for the foot. A small pin-point sinus was noted August 24; this exuded a drop of serum. The tendon strength was estimated now at 75 per cent. of the normal and dorsiflexion was full and strong. The tendon was slightly adherent to the fascia about two and one-half inches from its insertion point. September 19, a small incision was made over the sinus and a silk suture removed.

The patient was seen again in August of 1933. The tendon was perfectly normal in its action and strength.

Els<sup>2</sup> has pointed out that in the cadaver it is impossible to tear the tendon of the tibialis anticus, even by overpowering force. In the living, a tear of the tendon results, given a fixed leg and a sudden force in the direction opposed to the normal muscle pull, that is, a force in plantar flexion, acting upon a suddenly and strongly contracted muscle belly. The tear occurs with a straight knee, and the fixation of the leg does not reflect the trauma to the knee, for otherwise, as Brüning<sup>1</sup> says, a tear of the quadriceps tendon would come about instead. The mechanism was this in three of the cases. In our first case, the sudden dorsiflexion of the foot, especially as he stepped into the puddle of water heel first, was enough to cause rupture of a very probably degenerated tendon. No strong opposing force was necessary.

The amount of trauma producing the tear was variable. In the case of Els, a young stoker of twenty-five, in endeavoring to uncouple a train which was behind a small field locomotive on which he was riding, had his left foot caught in plantar flexion so that he could not release it. The leg was fixed. The trauma was strong enough to detach the tendon from its insertion together with a small fragment of bone. In the case of Brüning, a forty-five-year-old skier caught his right foot in a railing, fixing the foot in plantar flexion. The fall of the entire body forward tore the tendon of the tibialis anticus. In our second case, the trauma of the kick seems relatively mild; there was no immediate history of injury in our first case.

The tendon of the tibialis anticus is apparently very seldom involved by degeneration and the consequences of degenerative processes. The story of our first case bespeaks a degenerative, spontaneous tear, rather than a tear of typical trauma. An original trauma a year before had probably injured the blood supply to the tendon, and rupture of the tendon took place without external trauma over a period of two weeks in two acute episodes, the second of which led to complete rupture.

The tendon was examined at operation in two cases. In both, tear had taken place through the tendon substance itself, near the ankle-joint. In one (Brüning), the signs of old, and in the other (Mayer<sup>5</sup>), the signs of recent hæmorrhage was present. Brüning's description leads one to believe that the tear had occurred in a normal tendon. Mayer's case showed fibrillation of the tendon ends. Still this was no greater than one expected with the large intrathecal hæmorrhage noted and he saw no reason to consider this a degenerative tear. In neither case was a portion of tendon excised for examination. In Els' case, the tendon must be considered as otherwise normal.

## RUPTURE OF TENDON OF TIBIALIS ANTICUS

This then is in direct contradiction to McMaster's<sup>4</sup> statement that normal tendon cannot tear within its substance.

The clinical picture is a simple one. Pain immediately after the tear is usually not great, and may even be absent. Els' patient, however, experienced fairly acute pain. The pain is of surprisingly short duration. Walking is possible but is somewhat painful, and an immediate mild limp is noted. The foot is swollen over the course of the tendon and over the anteromedial aspect of the ankle-joint. Els' patient developed an extensive swelling slowly, so that it ultimately reached his mid leg. An immediate loss of power, especially a feeling of being unable to dorsiflex the foot completely, is present. The actual moment of tear is accompanied by a snapping sound and a feeling that something has torn within the foot. If the condition is untreated, a feeling of fatigue on long standing and walking develops. The sole of the foot flopped down in walking in one case. All cases occurred in males.

The signs noted are those due (a) to the actual trauma itself, (b) to the tear of the tendon, (c) and to the loss of function of the torn tendon.

Swelling and ecchymosis disappear rather quickly. In Els' case, the additional presence of dorsal luxation of all the toes was accomplished by the same trauma.

The prominent tendon of the tendon of the tibialis anticus is neither seen nor felt in its usual position, and this is made very evident by inverting and dorsiflexing both feet. The distal stump of the tendon cannot be felt but the proximal end is easily palpated in the region of the annular ligament, and is quite sensitive to pressure. The tendon itself and the muscle belly proper are also painful on pressure. Slight lateral mobility of the proximal tendon end is allowed. Tenderness is also noted at the normal insertion point of the tendon. The gap between the proximal end of the tendon and the point of insertion is large, and amounted to four and one-quarter inches in our first case. In the case of Els, in which chip fracture took place, further retraction of the tendon was not allowed because of the size of the detached bony piece. Electrical testing demonstrates also the absence of the tendon.

The functional loss of the foot is surprisingly small. Dorsiflexion at first may be limited by  $10^{\circ}$  to  $15^{\circ}$ , and, without suture of the tendon, is ultimately regained by the dorsiflexing action of the extensors of the toes. Supination is accomplished strongly by the action of the tibialis posticus. All motions of the foot, both in the operated and the non-operated cases, become normal or almost normal in a few months. Gait, at first accompanied by mild limp, rapidly becomes normal with or without suture of the tendon.

Two definite sequelæ are noted in unsutured cases—first, the development of a mild to moderate flat foot, and second, the presence of late ankle strain.

The two non-operative cases represent extremes. The young stoker, seen first nine weeks after his injury, was relieved by the conservative therapy of baking, massage, and the wearing of foot plates, so much so that four months later he was quite comfortable. This was also true of our first

MICHAEL S. BURMAN

patient, who, despite his age and the presence of the ruptured tendon, was able to walk long distances.

The simplest treatment is, however, the suture of the torn tendon, and a perfect end-result is thereby attained. The tendon ends should be united intrathecally by a strong tendon suture. The foot is put in plaster in dorsiflexion and inversion for a few weeks. A month after operation, Brüning's patient had full use of the tendon and six months later could go mountain climbing. Mayer's patient had a 75 per cent. return of power five weeks after operation. Five years later the foot was normal.

Tears of other tendons of the foot, except those of the tendo achillis and of the tendon of the plantaris, are equally rare. Camitz (quoted by von Stapelmohr<sup>3</sup>) reported an old tear of the tibialis posticus with a gap of eight centimetres between the tendon ends. This was successfully bridged by a strip of fascia lata several years after the actual tear. Tears of the extensor tendons of the toes apparently have not been reported, and in Els' case a dislocation of the toes dorsally, rather than a tear of the tendons, occurred. Meyer noted a fraying of the peroneus brevis tendon in a cadaver but rupture had not taken place.

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# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

STATED MEETING HELD JANUARY 10, 1934

The President, DR. ALLEN O. WHIPPLE, in the Chair

### HIGHLY MALIGNANT CARCINOMA OF THE BREAST WITH BULKY AXILLARY METASTASIS. TREATED BY IRRADIATION ONLY

DR. FRANK E. ADAIR presented H.B., a young lady, who came to him November 6, 1931 (two years and two months ago) at the age of twenty-seven years. At that time there was a mass situated in the inner lower quadrant of the right breast measuring three by three by two centimetres. The mass had all the physical signs of cancer. The axilla was largely filled from its base to a point near the sternoclavicular joint with bulky metastatic nodes varying in size, the largest being 2.5 centimetres in size. There was a suggestion of right supraclavicular fullness but no positive node could be palpated. The infraclavicular space was full on account of the deeper nodes.

A biopsy was made. Doctor Ewing termed it a very cellular, highly malignant carcinoma, probably about a grade IV on the scale of malignancy. On account of the bulk of axillary involvement, the age of the patient, and the highly malignant process, it was determined to treat by irradiation instead of operating. She received five high-voltage X-ray treatments beginning November 7, 1931, covering the breast and axilla. The breast tumor and the axillary mass began to diminish. February 5, 1932, he introduced five steel needles containing radium into the breast and axilla transversely and parallel. Between each needle he introduced a row of gold radon seeds. The total amount by radium was 11,235 millicurie hours, which is a very large dose. Following this, further reduction took place so that the tumor was almost impossible to palpate. During March, 1932, two high-voltage treatments were given, one directly over the tumor and the other over the axilla. By June, 1932, there was fluid in the right chest; the patient was uncomfortable not only from the painful pleurisy, but also from the intensity of the irradiation. Chest metastasis developed. The breast tumor disappeared completely; the axilla became perfectly clear. The pectoral muscle became atrophied and fibrosed. The breast became fibrotic. No nodes developed in the supraclavicular space. However, she developed an annoying cough that was difficult to control and she was very miserable. She weighed not over eighty-five pounds and was sent home to die.

During December, 1932, she returned to New York and they gave her two high-voltage X-ray treatments over the mediastinum for the persistent cough.

The patient began to improve and in September, 1933, she resumed her work as a teacher. Today there is fibrosis of the breast; and pectoral muscle. There is no positive evidence of local disease. The X-rays show pulmonary improvement but Doctor Herendeen believes there is metastatic chest disease still present although much diminished. This case is not presented as a cured case; but one of a desperate type treated along another line than surgery. Had irradiation not been employed he felt certain she would be dead long ago.

## NEW YORK SURGICAL SOCIETY

### EPITHELIOMA OF THE HAND SECONDARY TO IRRADIATION

DR. FRANK E. ADAIR presented J.S., a male, aged fifty-three years at the time he came to the Memorial Hospital January 1, 1933. The patient had been a salesman of X-ray machines and fluoroscopes thirty years previously. He used to demonstrate the fluoroscope by holding a metal key in his left hand before the screen. He received a rather severe burn of the hand and immediately stopped selling machines. Since that time he has had scaly, dry, shiney skin of the left hand. Several small wart-like lesions appeared on the dorsum of the hand. Five years ago he accidentally scraped the skin of the left hand, at the first proximal metacarpophalangeal joint. The wound never healed to date. There were several raised, roughened ulcerated areas scattered over the dorsum, and particularly about the nails of the first, second, third and fourth fingers, including the nail bed of the third finger. Numerous areas broke down and after a few weeks healed again. This process repeats itself. The lesions have the typical appearance of irradiation dermatitis and irradiation epitheliomas. The axilla was clear. He was started on a régime of hand hygiene and temporarily improved. January 6, 1933, three lesions of the dorsum of the hand were electrodesiccated, also one on the second finger. At the time the nail of the third finger was entirely gone and the bed so ulcerated that amputation was done just distal to the middle phalangeal joint. As long as he took extra care of the hands the lesions improved; but when water was frequently applied, and the vaseline was not consistently rubbed in daily, the lesions grew deeper, larger and more painful. He worked as a waiter during much of this time. During July, 1933, the fourth finger became so much worse that it was amputated through the proximal phalanx. During September, 1933, the index finger with its metacarpal were removed. The pathological reports were squamous carcinoma grade II. The irradiation epitheliomas occur usually many years after the original applications. They are ordinarily squamous carcinoma of low grade, grade I or grade II. The rare one is grade III or higher, in which case the metastasis is not only to the regional lymph-nodes, but widely to other parts of the body. In his service at the Memorial Hospital are ten such cases as this, among physicians, technicians and salesmen.

The dermatologists are producing a crop of X-ray epitheliomas by over-treatment, particularly of psoriasis.

Great importance in these hand cases lies in keeping the hands away from soap and water. The skin is already completely dried out, the oil glands having been destroyed by irradiation, so that every crack or minor injury results in very slow wound healing. It is important that this oil deficiency be supplied by the daily rubbing into the skin of some oily substance such as vaseline. It is wise if they sleep with cotton gloves on after having thoroughly applied the vaseline. Hand hygiene is of the utmost importance because this chronic disease is a progressive one. The electrodesiccator is of great value in treating small localized areas. Amputation of the entire hand becomes at times necessary. Metastasis to the axilla is comparatively slow and late in the course of the disease.

DR. GEORGE H. SEMKEN said the effect of the X-ray irradiation in these cases of "X-ray dermatitis" and resultant epithelioma is comparable to an aging process which has added many years to the age of the affected area. It results from (1) an obliterative endarteritis, with similar changes in the capillaries and the veins, and (2) the destruction of the appendages of the



## EPITHELIOMA OF THE HAND SECONDARY TO IRRADIATION

skin, notably the sebaceous and the sweat glands. The endarteritis, like arteriosclerosis, is a progressive disease and continues its advance even though the irradiation had been discontinued since many months or years. The early parchment-like dryness and atrophy of the skin are followed by increased atrophy and fibrosis as the vascular and degenerative changes advance; and with these, there are keratosis, warty growths, fissures and erosions in varying degree. Such a field of damaged epithelial tissue, with a diminished blood supply, repeated trauma, and continued irritation, furnishes a fertile soil for cancer genesis. Chronic irritation from other causes, in the various parts of the body, is followed by a relatively limited cancer incidence. In the areas of X-ray and radium damage, however, the eventual occurrence of cancer seems almost inevitable. Maud Slye has found in her stock of mice that the spontaneous occurrence of cancer tends to follow the Mendelian law of inheritance, with cancer the recessive and non-cancer the dominant factor—*i.e.*, the active factor in inheritance is protection against cancer. This "protection" probably explains the evident immunity of many people against cancer. In the oral cavity, for example, where diseased and broken teeth, bad hygiene, and the abuse of alcohol and tobacco invite an extensive cancer incidence, the actual occurrence is nevertheless relatively limited. The high incidence of cancer following damage to the skin by irradiation with X-rays and radium (and also from the repeated painting with tar, in animals), is believed by her to result from the destruction of this inherited protective mechanism.

The tragic experience of many workers in the X-ray field, and of these patients in general, compels an understanding of this problem and its intelligent management. It must be recognized, from the start, that spontaneous recovery is not possible, and that even the most painstaking care can only delay for a time the inevitable course of these tissue changes. This narrows the problem of treatment to two groups of cases, one, the *potentially* cancerous, and the other, the cases in which cancer has already begun.

In the first group it is useless to temporize with ointments and lotions, except, perhaps, in some mild cases in which this will give time to have the full extent of the lesion become evident. It is useless, also, to treat the keratoses and warty growths with the cautery, desiccation, or fulguration; and most unwise to attempt to cure these with radium. Early success with the radium treatment is followed by more intense tissue changes of the type that produced the disease. The objective sought in the treatment is the two-fold purpose (1) of relieving the patient from his painful and unsightly local lesion, and, more important (2) of prophylaxis against eventual cancer. This objective can be met only by the removal of the damaged skin and underlying tissue and its replacement by healthy skin. The small keratoses and warts can often be treated by excision and suture. Small damaged areas in regions not subject to stretching during movement (as over joints), may be replaced by a Thiersch graft if the underlying tissue is not greatly fibrosed. In the well-marked case, the logical and most practical procedure is the

excision of the damaged surface and the underlying fibrosed tissue, and their replacement by a pedicle flap of skin and fat. In the hand cases, such flaps are preferably taken from the lower axillary region, where the skin and the fat tissue are relatively thin. The flap primarily covers the hand as a large web, with the fingers spread widely apart; and after this has healed well in place, further adaptive procedures are added to restore the appearance and functional competence of the hand. An essential factor in such flap-transplant operations is the need to have the margins of the flap come into contact with well-vascularized, undamaged tissue, since an adequate blood supply from the base is usually not available. The line of tissue-excision, therefore, must be placed well within the healthy areas, so that there can be no question of a later failure of nutrition. What may seem to be a well-vascularized floor of the wound, at the time of the operation, may later undergo fibrosis and ischæmia from the progressive endarteritis caused by the irradiation. On the other hand, it has seemed that there has been improved vascularization in these deeper areas, following some such flap transplants, as if a new blood supply had been obtained via the flap.

When cancer occurs in these cases, it does not begin in the area of scar tissue (where the epithelium has been completely destroyed), but it begins in the areas of epidermis and the remaining appendages of the skin in which varying sublethal degrees of injury have occurred. The type of cancer is nearly always squamous or mixed cell; and squamous cancers tend to metastasize to the regional lymph-nodes. The early phases of this cancer addition are often not recognized; and the rate of growth is slow, as would be expected in such poorly vascularized, fibrosed regions. This, unfortunately, has led to reliance upon very limited procedures, and the usual experience in these cases is the history of many ineffective, small operations, ending as a major problem and with an unfavorable prognosis.

The treatment is entirely surgical, and the plan of operation follows the usual cancer requirement of a wide local excision plus the removal of the regional lymph-nodes, whether these are palpable or not. In the hand cases, the extent of the local excision depends upon the depth of the cancer invasion. When the involvement is limited to the skin, a wide excision of the skin, subcutaneous tissue and fascia about the lesion will be sufficient, and this defect may be covered by one of the flap transplants already noted, or at favorable times, by a simple Thiersch graft. When the invasion has extended to the tendon sheaths, tendons, or ligamentous structures upon the bones, amputations are required. These may be of individual fingers, or of the radial or ulnar segments of the hand, including the respective metatarsal bones. The complete loss of the hand is seldom necessary as a first procedure. The closure of the amputation wounds may require a sliding flap from the adjacent skin or, occasionally, from the chest region. The necessity for the removal of the regional lymph-nodes as part of the primary operation must again be emphasized. It should be remembered in the cancer cases, also, that the adjacent areas of irradiation damage have the potentiality of a future,

## NEUROGENIC SARCOMA EXTENDING FROM THE PELVIS

similar cancer addition; and that the prophylactic excision of such suspected areas forms a part of the surgical responsibility at this time.

DOCTOR ADAIR said that it is very difficult to have much success with skin graft in these cases because of the extensive ulceration of the nail beds and skin immediately surrounding the nails. This is due to the endarteritis of the skin vessels following irradiation. There is not sufficient good skin circulation in the hand for the grafts to take well. Irradiation dermatitis and irradiation epitheliomatosis are progressive diseases. Anyone with much experience in such cases becomes impressed with the fact that they require constant attention. After caring for the main lesions, it will become necessary to occasionally electrodesiccate one or two areas. Hand hygiene is of the greatest importance in preventing future development of the multiple lesions.

### NEUROGENIC SARCOMA EXTENDING FROM THE PELVIS TO A HAMMER TOE

DR. FRANK E. ADAIR presented a young lady, now aged twenty-two years, who came to the Memorial Hospital three years ago. The case illustrates the congenital nature (hammer toe) as well as the wide extent of *this type* of neurogenic sarcoma. She had the following congenital lesions: (1) wine-colored nevus of the vulva; (2) a brown nevus of the right neck; (3) a "hammer toe" on the left foot. On April 30, 1927, the toe had been amputated. In February, 1928, on account of a swelling of the stump of the toe, a portion of the metatarsal bone had been removed. September, 1928, a larger portion of the same metatarsal was removed at the New York Orthopedic Hospital. In February, 1929, she was again operated on and a large mass of fibrous tissue removed from the site of the former operations. The report of the pathologist was "fibroma" just as the previous reports had been. She went to Philadelphia, where she received eight X-ray treatments. In December, 1929, she first noted a tumor of the popliteal region of the same leg; it extended downward into the inner upper portion of the left leg. In January, 1930, she went to the University of Pennsylvania Hospital where the foot and the popliteal space were operated on. The pathological report was again "fibroma." Both tumors recurred. Two months before coming to our clinic she noted a growth in the posterior inner aspect of the thigh. On physical examination at the time of entrance an interrupted tumor process extended from the dorsum of the foot up to the femoral opening, being most bulky in the calf, the popliteal space and the thigh. The diagnosis of neurogenic sarcoma was made. The chest plate was negative for metastasis. It was felt by some of my colleagues that an amputation of any type would be futile, because they considered that probably the entire nerve trunks from the spinal cord down to the toes were condemned. January 30, 1931, a small tumor was removed for biopsy from the femoral triangle. It proved to be "neurogenic sarcoma, grade I, radio-resistant." This suggested that irradiation in this case would be of little value; and it was doubtful if amputation would prove curative. However, rather than send her away as a hopeless case, he did a hip-joint disarticulation February 18, 1931. This was followed by immediate transfusion. The sarcoma on the median aspect of the upper thigh was continuous with a tumor the size of a lemon which extended through the obturator foramen into the pelvis minor. This intra-pelvic tumor was not removed. On dissection of the

## NEW YORK SURGICAL SOCIETY

amputated member it was found that the tumor extended along and surrounded the sciatic and common peroneal nerves. In the popliteal region a mass thirteen by seven by four centimetres filled the space closely adherent to the periosteum. In the foot, the digital branches on the plantar surface were lined by numerous tumors one centimetre in diameter, which later fused into a bulky mass projecting between the metacarpal bones and appearing on the dorsum as a tumor six by six by four centimetres. Today this patient has not yet had metastasis to the lungs. There is no local recurrence. She has gained twenty pounds in weight. We feared that the intrapelvic tumor might become responsible for metastasis and local growth; but this has not occurred and the patient is in good condition locally and generally. Curiously enough, the intrapelvic tumor, originally the size of a lemon, gradually diminished in size for a year and a half following the disarticulation; at the end of which time rectal examination revealed no tumor present.

The case illustrates in a striking way several points:

(1) The very wide extent of this type of neurogenic sarcoma. Her disease was almost continuous from an intrapelvic tumor down to the original hammer toe.

(2) The congenital deformity or hammer toe so common in these familial diseases.

(3) She illustrates too well the story so common in this type of malignant growth, namely multiple, incomplete operations. This patient had six operations.

(4) It is interesting that every pathologist rendered a report of a "benign fibroma" up till the fifth operation, in spite of the fact that it recurred after each operation. It illustrates the difficulty encountered by the pathologist in the *microscopical* diagnosis of this tumor and further indicates that the surgeon should use his own judgment in outlining the therapy and not be "thrown" by the pathologist in handling neurogenic sarcoma.

There are 359 cases of neurogenic sarcoma in his service at the Memorial Hospital. The best treatment is pre-operative irradiation followed by *wide* local excision, later by post-operative irradiation. When necessary, radical surgery as the above case must be resorted to. Too commonly such cases are not correctly diagnosed by the operator and he therefore makes too narrow an excision.

DR. BRADLEY L. COLEY said that this case belonged to a type of neurogenic sarcoma, which is fortunately not frequently seen. It is of the type in which multiple tumors are found along the trunk and even the finer filaments of the peripheral nerves, some of these tumors being neurofibromata and others definitely neurosarcomata. This type is seen in patients who present other stigmata of von Recklinghausen's disease.

The more common form of neurogenic sarcoma, however, is characterized by a single lesion occurring in individuals without the stigmata of neurofibromatosis, and in these cases adequate extirpation at the first operation is frequently successful. Recurrences are common, however, because of inadequacy in attacking the lesion primarily.



## CHARCOT'S FEVER WITHOUT JAUNDICE

### CHARCOT'S FEVER WITHOUT JAUNDICE

MORRIS K. SMITH described intermittent hepatic fever described by Charcot in 1877 and often designated as Charcot's fever is known to all, although one may hope that in these days of early biliary surgery it is less frequently encountered than formerly. Due ordinarily to recurrent obstruction from stone in the common duct, it is characterized by pain, chills and fever and followed by jaundice in a day or two, or a deepening in its intensity if already present. Stones, on the other hand, may be dormant for a considerable period in the common duct and in the absence of obstruction and infection do not give rise to Charcot's fever. In a series of 1,608 cases of stone in the common duct which came to operation Judd and Marshall reported that chills and fever were present in 37 per cent. They were usually associated with attacks of pain and jaundice but in a few cases were the only symptoms present.

Dr. Smith presented a woman who entered St. Luke's Hospital in September, 1931, because of recurring bouts of chills and fever during the past seven weeks which she thought were grippy attacks. There had been some epigastric pain particularly at first, but it was not emphasized by the patient. Jaundice had not been noted. She had lost thirty pounds. Palpation of the abdomen revealed neither tenderness nor mass. During seventeen days' observation in hospital she had four sharp rises in temperature of short duration twice accompanied by chills or chilly feeling without severe pain and without the development of jaundice. Cholecystographical study of the gall-bladder showed absence of filling and the presence of a stone. The clinical picture was complicated by chronic arthritis.

While the cause of the fever was not altogether clear it was felt that a laparotomy was indicated. At operation October 2, the common duct was found strikingly dilated, easily admitting the gloved finger. At the lower end were two stones, the larger two by one centimetres, shaped like a blunt-nosed bullet and too large to pass through the ampulla, and a second smaller one. These stones were removed, the duct drained and the gall-bladder, which was thickened and contained stones, was removed. Convalescence was complicated by erysipelas starting in the breast and alveolar abscess. Recovery from the biliary-tract disease has been satisfactory.

It seems probable that the attacks of chills and fever experienced by the patient were due to recurring brief obstruction by the stones in the common duct. In considering this explanation the question arises as to how long an obstruction must be continued to produce jaundice. Mann and Bollman found that if the common duct of dogs was ligated in the presence of an intact gall-bladder the sclerotics did not develop an icteric tinge for from two to three days. When, on the other hand, the gall-bladder is removed at the time the duct is blocked there is no question about the animal being icteric by the end of the first twenty-four hours.

In the presence of a diseased gall-bladder as shown by this patient the effect of obstruction to the duct would doubtless be comparable to that in the cholecystectomized animal.

If one may argue from this analogy obstructive attacks of a few hours need not be productive of jaundice. The short duration of the fever is further evidence that in this case they were brief.

DR. RALPH COLP stated that the fact that stones may be present in the common bile-duct, in cases of cholelithiasis without producing symptoms, has long been appreciated. Recently Klingenstein, in a review of eighty-two



## NEW YORK SURGICAL SOCIETY

choledochotomies performed at Mount Sinai Hospital, found five cases of asymptomatic common-duct calculi, and Clute of the Lahey Clinic reported that 39 per cent. of patients with common-duct stones did not give a history of jaundice. Surgeons well acquainted with the compensatory dilatation of the biliary-duct system following a cholecystectomy have come to recognize that a common duct slightly thickened and wider than usual in cases of cholelithiasis and cholecystitis calls for careful exploration to exclude the presence of stones. In other words, an extensive dilatation of the biliary canals may exist even with the gall-bladder intact in cases of symptomless common-duct stones. It is this increased biliary reservoir which has been created, which makes the absence of clinical jaundice possible in cases of common-duct obstruction of short duration. Humans vary in their color dependent upon racial differences and very often in the darker type of individual, a high degree of bilirubinemia may exist without any of the clinical manifestations of icterus. The explanation which Doctor Smith offers in his unique case of silent common-duct stones with infection giving a modified Charcot syndrome is, therefore, most probable.

DR. SEWARD ERDMAN said, regarding the length of time and the number of hours necessary for visible jaundice to show itself, he reported a case ten years ago in which the common duct had been injured at the time of cholecystectomy. In that case the duct was found to be tied off. Jaundice was definite within twenty-four hours. Immediate operation was done, anastomosis made between the two ducts and the proximal end found with a ligature about it. In his case of sudden ligation there are certain factors that are absent in duct blockage of long standing. If there are stones in the common duct which may be obstructive, there occurs dilatation of the common duct and the whole duct system in the liver, and bile has a large area in which it may collect. The same thing is true in such a case as Doctor Smith's, where the gall-bladder is still present, and the appearance of jaundice may be delayed. In the case reported by Doctor Erdman no previous dilatation of ducts had occurred and, in addition, the gall-bladder had been removed, hence the direct damming back of bile in the liver may have caused the very early appearance of jaundice.

## CALCULUS ANURIA

DR. MORRIS K. SMITH presented a woman, aged thirty-eight, who came under his care at St. Luke's Hospital in October, 1932, with anuria of two days' duration. Seven years previously her left kidney had been removed for calculous pyonephrosis. She had remained well until the onset of the present illness. The anuria had been accompanied by pain, apparently not severe, in the right flank, there had been nausea, intestinal gas, and a chill and sweat the day of admission. On examination tenderness and spasm were noted in the right flank. X-ray showed a solitary stone in the right kidney pelvis. The blood urea was 55. A ureteral catheter was introduced to the right kidney by Doctor Hoch and left in. It established drainage and five days later the urea was 13. The course was moderately febrile. At the end of a week the catheter was removed but had to be reinserted the next day

## CALCULUS ANURIA

as anuria was again evident. After another week the temperature had approached normal and it was decided to operate. The phenolsulphonphthalein test was reported as 70 per cent. four days before operation.

A stone about 2.5 by 1 by .5 centimetres of a shape to engage the ureteropelvic junction and block it was removed by me through a pyelotomy incision. After four days all urine came through the bladder. Convalescence was marked by vomiting and weakness. On the seventeenth day post-operative the blood urea was 29 and on the nineteenth 28. The urine showed a heavy trace of albumen and pus. The patient was discharged to the convalescent hospital at the end of three weeks and while there gained seven pounds, apparently all of it œdema in the legs.

Three months after operation the œdema had largely cleared up but she still vomited at times. The blood urea was 21. Nine months post-operative she looked well. There was no œdema, although she had regained her weight. She reported occasional headaches and that the ankles swelled at times. The blood urea was 17. The urine showed a trace of albumen, occasional hyaline and granular casts and clumps of pus-cells.

This patient has made a good clinical recovery but she suffered from renal insufficiency for several months and it is this feature of the case which I hope may be discussed. Interestingly enough, the discharge noted at the time of her nephrectomy seven years before stated that there was slight œdema of the ankles. It does not seem at all surprising that a solitary kidney should be sufficiently damaged by the presence of stone block and infection to require some time to function adequately. He found little emphasis on this aspect of the situation. Cahill and Gile reported seven cases of calculous anuria and watched the recovery of the secretion in the six survivors. In all but one the return to approximate normal occurred within two months.

His only other personal experience with calculous anuria occurred in a much older woman who was very stout and chronically ailing. She had had one kidney removed years before. He removed a stone from the upper end of the ureter which was causing the anuria as well as several from the pelvis of the kidney. She recovered from the operation sufficiently to go home but died shortly after of renal insufficiency. There were, however, other stones left in this case and it is possible that further blocking contributed to the fatal outcome.

DR. JOHN DOUGLAS said that in 1917 he presented a case of calculus anuria before this Society, but his case differed from Doctor Smith's because the patient had a congenital absence of one kidney. Three years before her admission to the hospital she had had attacks of renal colic, and seven days before an attack of hæmaturia and there had been complete anuria for twenty-four hours before admission. Cystoscopy showed no urine in the bladder and no ureteral orifice on the right side. The diagnosis was obviously stone in the pelvis of a single kidney. Operation was performed without delay and a stone removed from the pelvis of the kidney where it joined the ureter. The patient made an uneventful recovery. Doctor Smith's case illustrates the damage caused to the kidney by obstruction. The more prompt the operation the less damage the patient will have in the kidney.

### PHYSIOLOGICAL CONSIDERATIONS RELATED TO THE INFUSION TREATMENT OF SHOCK

DR. WILLIAM F. MACFEE read a paper, written by himself and DR. ROBERT R. BALDRIDGE, with the above title for which see page 266.

# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

STATED MEETING HELD JANUARY 24, 1934

The President, DR. ALLEN O. WHIPPLE, in the chair

### CHOLELITHIASIS—CHOLECYSTECTOMY—COMPLICATED BY ABSCESS OF LESSER PERITONEAL SAC

DR. BRADLEY L. COLEY presented a woman, thirty-nine years of age, who was admitted to Fifth Avenue Hospital, March 20, 1932. During the previous three years patient had attacks of severe pain in the right upper quadrant accompanied by nausea and vomiting of large quantities of bile. The pain radiated across the epigastrium, through to the back and right shoulder. No extreme jaundice, but skin and eyes have had a yellowish tint. Has noticed no change in the color of the stools. Essentially negative except for appendectomy in 1925.

Physical examination is essentially negative. Examination of the abdomen reveals no areas of tenderness and no masses. Liver, spleen and kidney not palpated or tender. Lower right rectus scar well healed. She was operated upon March 21, 1932, at the Fifth Avenue Hospital under general anaesthesia. Pre-operative diagnosis: chronic cholecystitis and cholelithiasis. The gall-bladder bed and adjacent region were cloaked with adhesions, some thin and apparently recent, others organized and apparently of longer duration. The gall-bladder was thick-walled. It contained one large stone, two centimetres by one and one-half centimetres, smooth. The stomach, duodenum and colon appeared normal. The common duct was palpated; no stone felt.

Abdomen opened through an upper right rectus muscle-splitting incision. The gall-bladder was removed from above downward. Cystic artery and cystic duct ligated separately. A stab wound in the right flank was made, through which a cigarette drain was led to the stump of the duct and along the gall-bladder bed.

Microscopical examination of the gall-bladder showed considerable round-cell infiltration, oedema and congestion of the mucosa.

Following operation, patient ran a temperature between  $99.5^{\circ}$  and  $100.5^{\circ}$  for the first nine days, during which time there was a profuse drainage of bile, the stools being clay-colored. On the tenth post-operative day the temperature rose to  $102^{\circ}$ , pulse to 120 and patient vomited several times, bowels moving well after enemata, but the stools were still clay-colored. The retention sutures, which were cutting, were removed. On the fifteenth post-operative day the drainage was slight, no bile escaping from the stab wound. The patient was better in general, though temperature was still elevated to  $101^{\circ}$ . The following day the progress notes state that the wound is healing nicely, practically no discharge, but about 2 inches to the left of the umbilicus there is a tender mass which may be an abscess or a collection of bile. On the seventeenth post-operative day there was a discharge of purulent material from the stab wound which was noted as definitely different in character

## CHOLELITHIASIS—CHOLECYSTECTOMY

from previous drainage. At the same time the mass noted to the left of the umbilicus is definitely less tender and less palpable. Tubes were inserted in the stab wound. On the eighteenth post-operative day patient's temperature reached  $103^{\circ}$ , pulse 120 and the mass being still palpable it was decided to do a laparotomy for exploration and drainage of the abscess.

*Second Operation.*—April 9, 1932, under a pre-operative diagnosis of intra-abdominal abscess, probably of the lesser sac, the abdomen was opened with the patient under ethylene anaesthesia. A left rectus incision was made with its midpoint just below the umbilicus.

*Operative Procedure.*—Left rectus incision. Stomach presented in the wound and below it and behind it a firm mass the size of a large orange could be felt. This mass represented the walled-off abscess occupying the lesser sac and presenting most prominently in the gastrocolic omentum. The abscess was then opened by blunt dissection between the stomach and colon. Two cigarette drains were placed in the cavity after evacuation of a large amount of necrotic, odorless material. Cultures were taken and showed *B. coli* predominating. The laparotomy wound was then closed in layers about the cigarette drains.

Following this second operation the temperature and pulse were elevated to  $103^{\circ}$  and 140, but in the course of the next five days fell to  $100.5^{\circ}$  and 84. For ten days thereafter the pulse and temperature remained down. The patient began taking a liberal diet and there was a large amount of drainage of necrotic material through the left rectus incision from the abscess in the lesser sac. April 28, the thirty-eighth post-operative day, the temperature began to rise, reaching  $103^{\circ}$  with a corresponding elevation of pulse to 120, and this condition persisted for the following ten days. A transfusion of 500 cubic centimetres of whole blood was given by the Unger method. This was given because the patient's red blood-cells had fallen to 3,500,000 and hæmoglobin to 65 per cent. An injection of the sinus on the right side and also the one on the left was made with lipiodol. The Röntgen report on these films was as follows:

Films of the abdomen after the injection of lipiodol into the sinus on the left side show lipiodol puddling in the external aspect. There are no branches leading out from the main sinus. The sinus on the right side was injected and shows a small sinus tract running up to the bed of the gall-bladder. There is no communication between the two. The lipiodol does not communicate with any pockets outside of the main tract of the two sinuses.

May 11, the fifty-first post-operative day, a medical consultation was requested and accordingly Doctor Tenney examined the patient and found slight congestion of the pharynx, slight dullness over the right chest, a few, fine crepitant râles at the base and hoarse breathing over the bronchi. The presence of white blood-cells and a faint trace of albumin led him to suggest that a catheterized specimen be taken, and that the presence of bronchitis was an indication for radiographical examination of the chest. Films of the chest were accordingly made and showed no consolidation, but increased markings interpreted as due to a low-grade respiratory infection. There was no pleural exudate and no X-ray evidence of subdiaphragmatic abscess.

Since Doctor Tenney, on the basis of his medical consultation, and Doctor Pound, on the basis of his Röntgen studies following lipiodol injections, were both opposed to further surgical intervention, it was decided to pursue an expectant course. May 12, the fifty-second post-operative day, temperature and pulse began to fall, the temperature ranging between  $99^{\circ}$  and  $101^{\circ}$ , and the pulse between 80 and 120. This condition was maintained with



steady improvement for the next ten days and the patient was discharged on the sixty-ninth post-operative day. The left incision was rapidly closing, the stab wound for biliary drainage was discharging only a slight amount of bile and the stools contained a normal amount of bile. The urine was free from bile pigments. Patient was not jaundiced.

Following her discharge her wounds rapidly healed and she was able to return to work July 1, a little more than one month after her discharge. She has been observed during the past year and a half at frequent intervals, has had no digestive disturbance and the wounds have remained healed. There is no weakness of the original gall-bladder incision, but a slight weakness at the point where the lesser peritoneal sac was drained through the left rectus incision.

This patient is presented for the following reasons:

(1) Because of the rarity of this complication following a simple and comparatively easy cholecystectomy.

(2) The pre-operative diagnosis of lesser peritoneal sac abscess was made and substantiated.

(3) To emphasize the advantage of lipiodol injections in studying the late possible complications of cholecystectomy.

#### BILATERAL RUPTURE OF QUADRICEPS TENDON COMPLICATED BY DIABETES AND CARBUNCLE OF BACK

DR. BRADLEY L. COLEY presented a man, aged fifty-four years, who was admitted to the Hospital for Ruptured and Crippled April 14, 1933. He stated that while walking along a narrow walk he slipped and fell with the left lower extremity bent double under him. He tried to rise and walk, leaning on a companion, but his knee buckled under him and he fell backwards.

On admission, his general physical examination by systems was essentially negative except for the local condition. He was unable to stand or walk. He was extremely obese.

*Examination of Local Condition.*—There was an obvious depression above the left knee and a less marked one above the right knee. The palpating finger entered a depression which indicated a rupture or separation of the quadriceps extensor tendon on both sides, more marked on the left. There was marked tenderness in these areas, and complete inability to extend the lower legs or the thighs. *Urine analysis* on admission showed 2 per cent. glucose; no acetone. *Diagnosis.*—Bilateral rupture of quadriceps tendons.

Four days after his admission, the patient was operated upon; this interval was used in order to obtain a careful skin preparation. He was found to have diabetes, and the operation was done under spinal anaesthesia. Both sides were done at the same time.

On the left side there was a complete rupture of the quadriceps extensor tendon one centimetre above the patella extending through both medial and lateral expansions. The suprapatellar pouch was filled with blood-clot. On the right side there was a tear through the lateral expansion of the quadriceps tendon about seven centimetres in length commencing at the outer border and just above the patella; there was an inverted T-shaped extension of the tear upward for a distance of eight centimetres close to the lateral border of the patella. The suprapatellar pouch was filled with blood-clot.

(1) *Left side.*—A curved horizontal incision was made just above the superior border of the patella, the tendon exposed, and blood-clots removed. The patella was drilled, and a kangaroo-tendon mattress suture was passed through the patella and the proximal portion of the tendon above the tear.



## BILATERAL RUPTURE OF QUADRICEPS

Thus approximated, the tear was then closed with interrupted chromic catgut sutures and the skin with continuous silk; no drainage.

(2) *Right side.*—The same transverse incision was used with a vertical extension upward to expose the vertical tear. Repair was effected by a mattress suture of kangaroo tendon including above the two corners produced by the vertical tear. Interrupted chromic catgut sutures were then used to reinforce the mattress suture. The skin was closed with silk. No drains were used. Posterior molded plaster splints were applied with the legs in complete extension.

Following the operation the wounds healed by first intention and the local condition remained excellent. However, his post-operative condition was complicated by his diabetes which became markedly worse, requiring insulin and dietary restriction. By the twelfth post-operative day he was sugar-free. On the twenty-ninth day, however, he developed a huge carbuncle over the right side of the back near the scapula. The blood sugar rose to 250. Four days later the carbuncle was opened by crucial incision with undermining of the flaps. Two days later we learned from the laboratory of the Post-Graduate Hospital that the culture showed hæmolytic *Staphylococcus aureus* and that bacteriophage was likely to be of value. Accordingly we placed the contents of two ampoules in the wound, and administered one-half cubic centimetre subcutaneously.

There was improvement at once. The blood sugar was 158 on the following day and the patient felt better; he seemed less toxic. In all, six ampoules of bacteriophage were used, and May 26 the urine was sugar-free. Three days later a further incision was required to open an extension of the process, and the entire area was Dakinized for ten days. Thereafter, healing was slowly progressive, and the patient was finally discharged July 12, three months after his admission. He was readmitted August 7 for a skin graft of the unhealed portion. The graft took nicely and in a few weeks the entire area was healed. His diabetes has been controlled by diet alone since his discharge, and he returned to his former occupation of signalman October 1. He has full extension of the legs with good power.

This patient is shown because of the rarity of bilateral rupture of the quadriceps tendon; and to illustrate the severity of the complications that may follow surgical procedures on a diabetic.

DR. JOHN H. GARLOCK stated that the functional result in this case was exceptionally good. From the nature of the violence, most patients would, under ordinary circumstances, have sustained a fracture of the patella. However, in all the reported cases of quadriceps tendon rupture, and in two cases observed by the speaker some years ago, the patients were invariably in the fifth or sixth decade of life. It is probable that secondary changes occur in the tendon to permit of rupture of the tendon instead of fracture of the patella. In the two cases mentioned, Doctor Garlock noted an atrophy of the tendons with fat infiltration. He wondered, therefore, if such a condition did not also exist in Doctor Coley's case, and asked whether specimens had been taken for microscopical examination.

DR. GASTON A. CARLUCCI said that on looking up the records of these cases he found none under the age of fifty; it was interesting to note that the patient presented here tonight was fifty-four years of age. In a case of his own of extensive rupture of the quadriceps tendon he was not able to

## NEW YORK SURGICAL SOCIETY

approximate the tendon with the patella by using kangaroo because of further tearing, but was able to accomplish it by using fascia lata sutures.

DR. HUGH AUCHINCLOSS referred to a case of bilateral rupture of the quadriceps tendon above the patella in which one side, the less severely injured, had already been operated upon. Approximation was accomplished by using a long strip of fascia lata around the patella below going through the patella tendon and weaving it into the muscle up above. This patient also was over fifty years of age. The result was a good one functionally, and he can walk about, go upstairs and climb without difficulty. On one side, allowed flexion a bit too soon, extension is not quite complete. On the other side extension is apparently normal.

### DUODENAL FISTULA

DR. ARTHUR S. McQUILLAN presented a colored man, aged twenty-nine, who was admitted to Bellevue July 27, 1933, having been stabbed in the abdomen with an ice pick forty-eight hours before. He was given T.A.T. and observed by his own doctor before admission. For the thirty-six hours before admission, there was griping, aching and occasional sharp pain, mostly on the right side of abdomen. There were four attacks of vomiting, each after ingestion of food or water. No hæmatamesis or melæna were noted. There was a small puncture wound midway between xyphoid and umbilicus in right rectus area. Right abdomen was spastic, left was relaxed. There was no cellulitis of abdominal wall. There was slight shifting dullness in flanks. Temperature  $100^{\circ}$ , pulse 90. Urine was negative. White cell count total 21,000—96 per cent. polymorphonuclears.

An exploratory operation was done on the day of admission with the following findings: There was a moderate amount of clear straw-colored fluid on opening the peritoneum. There was a slight abrasion on the anterior surface of the stomach near the greater curvature and about two and one-half inches from pylorus. There were several areas of fat necrosis involving the gastrohepatic omentum and about the foramen of Winslow. The second part of the duodenum was well seen and found to be covered with a small amount of fibrin which was easily removed. No perforation of any organ could be made out. The abdomen was closed with a cigarette drain to the foramen of Winslow.

For the first thirteen days post-operative the patient did well, although running a temperature between  $100^{\circ}$  and  $101^{\circ}$ , falling to  $99^{\circ}$  on the twelfth day. At times the abdomen was slightly distended, but always soft and no tenderness. The drainage was of a serosanguineous nature and only a moderate amount. The patient took a satisfactory amount of nourishment and there were daily bowel movements. The healing of the abdominal wound progressed satisfactorily, the drain being gradually shortened and removed on the sixth post-operative day.

On the fourteenth day post-operative, after patient had been up and about, temperature went to  $104^{\circ}$  following a chill, with pain and slight tenderness in the region of incision. The patient was relieved with the application of heat and the next day the drainage was more profuse and purulent in character. There was a drop in temperature. A soft rubber drain was introduced for about three inches at the old site of drainage.

From the fifteenth to the twenty-ninth post-operative day, there was a variable amount of drainage purulent at times and flaky in nature. Tem-

## DUODENAL FISTULA

perature varied between  $100^{\circ}$  and  $102\frac{1}{2}^{\circ}$ . There was occasional vomiting and distention. Also there were days of some improvement.

White cells were 19,400, 80 per cent. polymorphonuclears. Liver dullness in right midaxillary line was higher than normal, and X-ray showed diaphragm about two inches higher than normal on this side, with obscuring of right border of psoas muscle and kidney outline. Urine was found to be normal. Methylene blue given by mouth appeared in the drainage, thus establishing a perforation of a hollow viscus with possible subdiaphragmatic abscess.

August 29, 1933, the old sinus tract was explored under general anaesthesia. It led down to second portion of duodenum, where dense scar tissue was felt. There was a moderate amount of purulent material evacuated. This had the character of small intestinal contents. A cigarette drain was placed down to the duodenum and another to the right kidney region. The following day there was profuse bile-stained drainage, typical of duodenal fistula.

Suction of the wound and application of Koolin to the skin were used to prevent excoriation. For the next fifteen days the patient took a downhill course in spite of adequate suction, frequent infusions and clysis, transfusions and the forcing of water and food by mouth. It was noted that practically the entire mouth intake was recovered in the drainage bottle. Hence all nourishment came through the fistula and the problem was to divert this stream into the small intestine. A duodenal tube was introduced into the stomach with the hope that it would slip by the duodenal perforation. For some reason the tube would not leave the stomach as evidenced by X-ray. A right-sided parotitis then made its appearance, but fortunately subsided in five days.

The patient lost weight, became weaker and thus faced starvation. On the sixteenth day following the second operative procedure he was made to partially sit up in bed, placed on a regular soft diet, and the fistulous tract was packed with plain gauze packing. For the first day or two, the drainage soaked through the packing to a slight degree, but thereafter the drainage was completely controlled and the tract healed with astonishing rapidity.

DR. GASTON A. CARLUCCI said that it was questionable if this fistula was the result of the stab wound. Something may have happened as a result of pressure from drainage on a traumatized duodenum. Fistulae have occurred following trauma in operations on the gall-bladder or kidney and they constitute a serious condition. The majority of the patients die. There were six on Doctor McCreery's service at Bellevue Hospital in the last fifteen years and only one survived. It was believed that this life was saved because of the complicated treatment of the fistulous tract which was packed with meat juice kept moistened with hydrochloric-acid solution. There was healing finally. The speaker believed that Doctor McQuillan's postural treatment and the soft diet was the proper procedure. The dehydration is so fast in these cases that the patient rapidly goes out unless properly treated immediately.

DR. SEWARD ERDMAN said that about twelve years ago he reported such a case before this Society. The patient was standing behind a truck and another car backed slowly into it and he was caught between, the tailboard

## NEW YORK SURGICAL SOCIETY

of the truck striking him in the epigastrium. As it was believed the liver was ruptured he was operated on at once. The duodenum was torn in the retroperitoneal portion where healing is so poor, and despite the suture repair, on the third day he developed a complete duodenal fistula and everything ingested came out almost immediately. In the treatment there were several points of similarity to that of the patient presented this evening. He was deprived of fluid by mouth and he developed parotitis. The chief point of interest, however, was that he became desiccated so rapidly. When he came to the hospital he was a well-nourished young man twenty-two years of age and he withered day by day like a flower out of water. Fifty to sixty ounces of fluid per day were collected from the fistula. He was given considerable fluid intravenously. Finally it was decided to make use of the secretions he was losing. A formula was arranged amounting to 1,200 calories including dried milk, glucose and olive oil dissolved in the duodenal secretions, collected in a sterile bottle. A jejunostomy was performed and the solution was fed back to him by the nurse through the jejunostomy tube. The immediate response in appearance and well-being was most striking. Nothing more was done and the fistula healed of itself. Doctor Erdman questioned whether the treatment by posture and diet had much to do with closure in Doctor McQuillan's case. Rather, he thought it had come to the period where it was about to heal spontaneously.

DR. RICHARD LEWISOHN said that several years ago, before this Society, he reported a case of duodenal fistula following an operation for stricture of the common duct. Two or three days after operation the patient developed a complete duodenal fistula. The treatment suggested by Dr. Seward Erdman (aspiration of the fluid and reintroduction through a jejunostomy tube) was adopted and the patient made a good recovery. At the Pathological Conference at the Mount Sinai Hospital Doctor Klemperer presented an interesting case of complication following operation for gangrenous appendicitis. In the post-operative course two subhepatic abscesses developed, one on the right side, one on the left side. The patient died seven weeks after operation. Post-mortem showed that the abscess on the right side had perforated into the duodenum, whereas the abscess on the left side had perforated into the stomach. Doctor Lewisohn stated that Doctor McQuil-

DR. JOHN C. A. GERSTER said that there was still another procedure for treating duodenal fistulæ which might be borne in mind, namely gastroenterostomy with pyloric exclusion. About thirty years ago Dr. A. A. Berg had a case of duodenal fistula, using this procedure with a successful outcome.

### CHOLECYSTECTOMY COMPLICATION—DRAINAGE OF BILE INTO LESSER PERITONEAL SAC—RECOVERY

DR. ARTHUR S. MCQUILLAN presented a woman, thirty years of age, admitted to Bellevue Hospital November 18, 1932, complaining of pain and soreness in right upper quadrant of abdomen. The pain was severe in nature



## CHOLECYSTECTOMY COMPLICATION

and radiated to anterior chest and right scapula. It was often relieved by vomiting.

There had been several such attacks in the past eight months. There was no history of jaundice or clay-colored stools. At this time there was no temperature, and the only positive findings on physical examination were an extremely obese patient with marked tenderness in right upper quadrant. X-ray did not reveal stones, but a gall-bladder that did not visualize. Drainage revealed no B. bile. Non-protein nitrogen, 33; sugar, 76; cholesterol, 170; Vandenberg, negative; urine, negative; white cells, 10,000; polymorphonuclears, 82 per cent.; bleeding time, three and one-quarter minutes; clotting time, three minutes; Wassermann, negative.

November 26, 1932, eight days after admission, patient was operated on for gall-bladder disease with findings as follows; gall-bladder eight times normal size, wall thick and gray in color; under slight tension and filled with small stones, one large stone in ampulla; no adhesions; common duct normal.

*Procedure.*—Through an oblique incision, the gall-bladder was removed fundus first. The stump of cystic duct was tied off with a transfixion stitch of No. 2 chromic, the artery being ligated separately. A cigarette drain was placed to the stump of cystic duct and abdomen closed in layers. In this case exposure was good. The gall-bladder cystic and common ducts were easily seen. The operation proceeded without difficulty and there were no accidents.

*Pathological Report.*—Chronic inflammation of wall of gall-bladder, lumen filled with stones and dark green bile.

Following operation, there was a slight temperature reaction for the first three days, otherwise convalescence proceeded in a normal manner. Drains were first shortened on the third post-operative day and each day thereafter until the sixth post-operative day when they were removed. There was a moderate amount of serosanguineous discharge, but never any bile. The wound healed normally.

The patient apparently did well, and made no complaints until the tenth post-operative day, when she called attention to pain in region of the left shoulder. This continued for the next four days and as no reason for it was discovered, aspirin was given, with no relief. On the fourteenth post-operative day, the patient was allowed out of bed for the first time, but she complained of much weakness and dyspnoea. It was noted that she was extremely pallid, that her pulse was quite rapid, though her temperature was normal and that she still complained bitterly of the left shoulder pain. Hæmoglobin, 85 per cent.; total reds, 3,850,000; and total leucocytes, 9,850. The next day (fifteenth post-operative day) the patient again complained of pain in left shoulder, was extremely dyspnoeic, had a pulse rate of 130 and weak in quality. She was extremely pallid but not jaundiced and appeared to be in somewhat of a state of shock. She refused food and stated that when she ate or drank anything, the shoulder pain was worse.

On physical examination the abdomen was found to be normal with exception of operative scar which was practically healed except a two-inch granulating area at drain site. The pulse and heart rate were regular, but 130 in rate. The heart sounds were distant and rather poor in quality. The chest showed absolute flatness up to the spine of scapula on both sides. The chest was tapped on both sides in eighth space in midscapular line, 400 cubic centimetres of what appeared to be pure bile was obtained on the right and 100 cubic centimetres on the left. The laboratory later reported this fluid bile. The patient was much relieved, especially in regard to dyspnoea and shoulder pain. However, the symptoms returned the next day, and again



the chest showed signs of fluid and was again tapped with the same result; about the same amount of bile obtained with relief of symptoms. On this day, however, there was an area of extreme tenderness and rigidity on pressure in the epigastrium. This was noted now for the first time, as the abdomen had been carefully examined each previous day. X-ray films of chest were taken, but were unsatisfactory due to obesity of patient and her semi-reclining posture in bed. Any other posture aggravated the symptoms.

Surgical exploration was then decided, on the assumption of inadequate drainage and retention of bile in the peritoneal cavity. The bile obtained on tap was still puzzling, as patient was absolutely free from jaundice. The patient was in the process of preparation for the operating room when Doctor Mayer, of the Ruptured and Crippled Hospital, came along and related Doctor Coley's experience. This added to the justification of our operative procedure which was as follows.

On the sixteenth post-operative day, under gas-oxygen anaesthesia, wound was opened along old drainage tract. A slight amount of seropurulent fluid escaped from the abdominal wall layer. On opening the peritoneal cavity, the great omentum appeared slightly bile-tinged. There were a few adhesions about the foramen of Winslow, otherwise the gall-bladder bed was negative. The gastrohepatic omentum was found bulging at the upper angle of the wound and bile stained. On opening this a great quantity of bile escaped. Drains were placed to gall-bladder bed and into lesser peritoneal sac and abdomen closed.

There was a stormy period for a few days; temperature,  $104^{\circ}$ ; pulse, 140 to 160, and of small volume, pallor and dyspnoea. This was followed by a progressive improvement until the twentieth post-operative day when there was a backing up of drainage, accompanied by a high pulse, temperature and increased dyspnoea. A drain was replaced along the old tract leading to the lesser peritoneal sac. This was followed by a progressive and complete improvement of the patient, the wound healing and discharge from the hospital on the thirty-eight day following second operation.

The following facts in this case are especially noteworthy.

(1) Pain in left shoulder, which was the first complaint and was given no consideration.

(2) Early pallor, almost a shock-like appearance, resembling that seen in acute pancreatic lesions, followed by rapid pulse out of all proportion to temperature.

(3) Then dyspnoea and a sense of fullness in the epigastrium, which with pain in shoulder, were intensified after ingestion of food or drink. This should have been an important clue, but its significance was recognized only after operation.

(4) The extreme elevation of diaphragm, permitting the chest tap needle to enter the lesser peritoneal sac. Unfortunately, the X-ray films were not good enough to show this.

(5) A tender area with muscular rigidity as a late symptom.

(6) The tendency of fluid under pressure in the lesser peritoneal sac to escape through the gastrohepatic omentum rather than through the foramen of Winslow.

(7) A possible simple explanation of this complication in this case is that the drain to the stump of the cystic duct either slipped beyond into and perhaps partially through the foramen of Winslow, or was accidentally placed further in this direction than was the intention of the operator. With the formation of adhesions plus the aid of gravity, it is reasonable to assume

## CHOLECYSTECTOMY COMPLICATION

that bile drainage went the easier way through the foramen of Winslow into the lesser peritoneal cavity, rather than upward along the part of the drain leading to the skin surface. This seems the more reasonable since there was no bile drainage following the primary cholecystectomy operation.

DR. JOHN V. BOHRER said that he had for some time been particularly interested in the complication of gall-bladder surgery that had been shown by Doctor McQuillan. During the time that he was house surgeon at Bellevue Hospital, a cholecystectomy for gall-stones, together with exploration of the common duct, was done by Doctor Hartwell. This case was drained by a tube in the common duct and a rubber dam drain in the gall-bladder fossæ. During the first thirty-six hours the drainage of bile was very profuse. By the third day the drainage had diminished gradually. On the fourth day there was a very small amount of drainage. In spite of the fact that the patient's temperature was  $99^{\circ}$  and his pulse not above 84, it was evident that he was not doing well. The abdomen was not distended and there was no vomiting. The patient was very listless and refused to take food. The fifth and sixth days were passed in this same listless way. There was no distention of the abdomen, the pulse remaining below 84 and the temperature remaining below  $100^{\circ}$ . On the morning of the seventh day the patient vomited and his stomach was immediately washed and large quantities of bile were removed. He rapidly became worse, the temperature rising to  $102^{\circ}$  and the pulse to 150. He died about six hours after his first attack of vomiting.

Clinically it was impossible to determine the cause of death. At autopsy a huge collection of bile was found in the lesser peritoneal sac. The peritoneal lining of this sac showed evidence of a marked peritonitis. There was a perforation through the gastrocolic omentum through which bile had passed into the general peritoneal cavity. This had not been in the general peritoneal cavity any great length of time as there was little, if any, peritoneal reaction. The pelvis contained a considerable amount of bile.

Since that time, Doctor Bohrer said, he had been interested in this peculiar complication and had carefully watched such cases of his own and had asked a number of surgical friends if they had ever encountered such a complication. Up to the time of seeing the case Doctor McQuillan had shown, he had not seen a similar case. Recently, however, Doctor Siris had had one such case with a fatal outcome.

Since liquids flow in the area of least resistance, it is not at all peculiar that the bile should drain into the lesser peritoneal sac, and one wonders why it does not occur more frequently. But, in the case here cited, and also in Doctor McQuillan's case, there was an added condition: namely, the bile had drained into the lesser peritoneal sac and was there under tension. Theoretically to explain this, one must assume that the tissue had formed a ball valve at the foramen of Winslow which allowed ingress but prevented outgress and this, together with the bellows action of the diaphragm, explained how this hypertensive hydroperitoneum could be produced. In fact, it is

very comparable to the formation of a hypertensive pneumothorax in the presence of a collapsed lung with a valve bronchopleural fistula. In Doctor McQuillan's case the pressure was so great that there was a distinct bulge from this space and in the case here cited, the pressure had been sufficiently great to actually cause a rupture of the omentum.

The next question of interest in this complication was what caused death if these patients were not reoperated on and drained. In reviewing the literature on biliary peritonitis, Doctor Bohrer found an Italian article by Doctor Figurelli in which he had done some experimental work on animals with bile peritonitis. He first laparotomized dogs, ligated the supraduodenal portion of the choledocus and incised the gall-bladder. Cultures of the bile were negative. All of these dogs died within twenty-four hours and all presented a marked bile peritonitis. He then used sterilized bile as well as bile taken directly from a healthy dog's gall-bladder and injected it into the peritoneal cavity of guinea-pigs and dogs, and in each instance death occurred within six to eight hours if the peritoneal cavity was not drained and more than three cubic centimetres of bile per kilo of body weight were injected into the peritoneal cavity. This bile peritonitis simulated an infectious peritonitis, but that it was due to the chemical presence of the bile rather than infection was proven by sacrificing the animal before sufficient time had elapsed for it to die from the peritonitis, at which time the fluid in the peritoneal cavity was found to be free of organisms, while the animals that lived through the natural span and died as a result of peritonitis invariably showed micro-organisms in the culture. This experimental evidence was well substantiated by the rapid demise of Doctor Bohrer's patient following the rupture into the general peritoneal cavity, which caused a generalized chemical peritonitis.

#### PLASMA-CELL TUMOR OF THE BREAST WITH METASTASES

DR. CONDUCT W. CUTLER, JR., presented a woman, aged forty-nine, who was in June, 1932, under treatment by her physician for lues. She discovered at this time a lump in the left breast. There had not previously been any pain or soreness, nor had there been any remembered injury to the breast nor any difficulty during the lactations which had followed her two pregnancies. The mass discovered was about two inches in diameter, firm and rather well fixed in the breast tissue. It was thought to be inflammatory in nature. Her physician removed the lump employing local anæsthesia. It is said to have been non-encapsulated and seemed to be invading the breast tissue. The tumor was examined and sectioned at the laboratory of the Roosevelt Hospital and pronounced plasma-cell tumor of the breast. This opinion was concurred in by the laboratory of the Memorial Hospital.

March 1, 1933, the patient was admitted to the Roosevelt Hospital complaining of increasing hoarseness for a period of three months. An ovoid growth about the right vocal cord was discovered. The Wassermann now was negative. March 4 a tracheotomy was performed, and this was followed by removal of the tumor of the larynx. Recovery was uneventful. Pathological examination of the tumor revealed its character as identical with that of the original tumor of the breast.

Shortly after discharge the patient began to complain of a painful swell-

## PLASMA-CELL TUMOR OF THE BREAST WITH METASTASES

ing in the region of the left sternoclavicular joint. She was admitted to the hospital May 24, 1933. There were no other complaints and examination showed no other abnormality. The mass itself was about the size of an egg, firm, rounded, not attached to the skin or bone, but fixed to the fascia. Under local anæsthesia the mass was removed, together with a small adherent portion of the pectoralis major. The pathological report was plasma-cell tumor. It seemed identical with the tumors previously removed.

Following this operation the patient was followed at recall clinic until September 12, 1933. At this time she was readmitted to the hospital for removal of a small tumor mass at the upper right border of the left breast. This mass was just to the left of the sternum at the level of the second rib. It was fixed to the deep fascia. The skin was free over it. Firm lymph-nodes were found in the left supraclavicular and axillary groups. The mass, about the size of a small egg, was hard and fixed to the fascia, extending into the muscle plane. It was removed under local anæsthesia. The pathological diagnosis was plasma-cell tumor.

September 25, 1933, the patient was recalled to the hospital and X-ray examination made of all long bones and pelvis. No abnormality or evidence of primary lesion or metastasis was found. Complete blood chemistry, blood count and study of blood smears gave normal findings. There was no suggestion of plasma-cell leukemia. X-ray therapy of the upper chest and cervical region was prosecuted from October 14 to November 1.

The patient continued to be followed at recall, the last note, bearing date of December 14, 1933, indicated no evidence of recurrence in breast, axilla or neck. Some pre-tracheal thickening was observed, but the larynx appeared to be much improved. Examination by the laryngologist, however, revealed a filled right antrum. From it a mass of tumor tissue was found invading the nostril, which was practically occluded. January 20, a fragment of this tumor was removed for examination. The pathologist reports it to be plasma-cell tumor.

This case may be considered to demonstrate either one of two facts. If it be agreed that it represents a true instance of plasma-cell mastitis at its inception, then it would appear that this condition is capable of metastasizing and is therefore potentially malignant. If the diagnosis is considered incorrect, then it serves to emphasize Adair's contention that the pathological differentiation of the condition may be exceedingly difficult and shows that the greatest care must be exercised not to confuse plasma-cell mastitis with a morphologically similar but very malignant neoplasm.

Much interest has been evinced of late concerning this pathological condition of the breast known as plasma-cell mastitis. The condition was described by Adair in an article published in the Archives of Surgery in May, 1933, (vol. 20, pp. 735-749). The summary of his article is quoted.

"A study is made of a lesion of the breast which we term plasma-cell mastitis. Ten cases are analyzed. This lesion is difficult to distinguish from mammary cancer by clinical signs alone. The signs of cancer are present, such as hardness of the tumor, retraction of the nipple, skin attachment, peau d'orange appearance and axillary nodes. With such signs present, the only possibility of arriving at a correct diagnosis lies in the evaluation of the characteristic history. The typical history is that at some preceding date an inflammatory process was present in a nonlactating breast, which process was accompanied by redness, mild tenderness and mild discomfort. As the symptoms of the acute phase pass off, a residual hard mass remains. This mass is not tender or painful. In eight of our ten cases, mastectomy was performed because of the difficulty of diagnosis. The lesions had most of



the signs of mammary carcinoma. The present analysis of our cases shows, however, that this is a diagnosable lesion clinically. The microscopical interpretation is very puzzling, as at times the lesion closely simulates comedo-carcinoma and at other times tuberculous mastitis. It is a pre-cancerous lesion and should be treated by local removal only."

Dr. James Ewing in his pathological interpretation of the condition—in the same article—points out that the cases reported belong in the general class of chronic or subacute inflammation of the duct system of the breast. He points out that the main gross anatomical feature is the presence of many much thickened ducts which are filled with puriform material. The cellular exudate, he says, is diffuse, making a broad, opaque, sometimes yellowish tumor-like mass. He further describes the plasma-cell exudate as beginning in the walls of the ducts and extending between acini in adjoining lobules when the process becomes diffuse. Proliferation of the lining epithelium of the ducts is, he says, a peculiar and prominent feature. Six to ten rows of large hyperchromatic epithelial cells line the ducts, often raising the suspicion of carcinoma of the duct. From these proliferating lining cells giant cells are often formed.

Adair describes the infiltrating plasma-cells as having a granular cytoplasm with an eccentrically placed nucleus. These cells occur in broad sheets invading the ducts, the walls and the interstitial tissues.

The case here presented, seeming to fall by clinical and pathological criteria within this group, presents certain variations from the type which may be of interest.

DR. FRANK E. ADAIR said that this case of Doctor Cutler's represents an extremely rare and interesting condition. Doctor Ewing and the speaker have studied in great detail the microscopical slides from each of the original and the two metastatic tumors. The ten cases reported in the Archives of Surgery, May, 1933, were all benign lesions. In those cases the plasma-cell infiltration had followed an inflammatory process of some months or years preceding. The plasma-cell is a wandering cell which invades tissue representing a chronic inflammatory process. Occasionally the plasma-cell is seen as a malignant cell in other parts of the body; but this case of Doctor Cutler's was the first instance seen by the speaker of the possibility of the plasma-cell becoming malignant in the breast. The metastasis to the cervical nodes and to the larynx would have to classify this as a malignant process. One sees the plasma-cell becoming malignant as evidenced in cases of plasma-cell myeloma of bone. This process at first strongly simulates a chronic low-grade osteomyelitis. One case of plasma-cell myeloma of bone on which Doctor Adair operated had multiple perforations through the periosteum and cortex leading down to the medullary portion of the femur. Doctor Ewing is of the impression that plasma-cell changes occur chiefly in fat areas. He gives as examples breast and bone. In the ten cases referred to above there was extreme difficulty, in most instances in arriving at a microscopical diagnosis, as well as a clinical diagnosis. There is always a heaping up of the lining-duct cells, sometimes as high as eight or ten rows deep, simulating comedo-carcinoma. It was considered in Doctor Cutler's case that this might be a



#### IMPORTANT FACTORS OF CHOLECYSTITIS

definite comedo-carcinoma which had metastasized; but after careful study of the individual cells, the opinion was arrived at that there was a gradual mutation from this plasma-cell into a metastasizing malignant tumor. This is the only instance in medical literature of such a case, and it seems to be entirely authentic. What is the proper treatment for this malignant plasma-cell cytoma? It is obviously necessary to operate at first to establish the diagnosis as the lesion so closely simulates clinical cancer. However, metastasis having occurred and been proven by subsequent operative removal, Doctor Adair ventured the opinion that it would be wise to irradiate rather heavily in the original lymph-drainage areas. This is not an epithelial tumor which has become malignant, but is a malignant tumor from a wandering cell forming itself into a malignant plasma-cell cytoma or may be called a plasma-cell sarcoma.

DR. WILLIAM CRAWFORD WHITE said that the chief interest in Doctor Cutler's case lies in its relationship to Doctor Adair's original paper. Doctor Adair had collected ten cases of plasma-cell mastitis. From a study of these he concluded that they should fall into the benign group, although he admits of the difficulty of diagnosis. Doctor Adair's final judgment was based on the microscope, for he has described the gross similarity to carcinoma. Eight of his cases, however, had had at least mastectomy, some of them radical mastectomy, and Doctor White wondered if one may not conclude that there were cases of cure of malignancy by surgery. Also, in view of Doctor Cutler's case of unmistakably malignant metastases, was there ever justification for local excision alone? If one in eleven is malignant, the correct treatment is that which one is prepared to direct against malignancy.

#### IMPORTANT FACTORS IN THE SURGICAL TREATMENT OF CHOLECYSTITIS

DR. HENRY F. GRAHAM read a paper with the above title, written by himself and DR. HENRY S. WATERS, for which see vol. 99, p. 893, ANNALS OF SURGERY.

DR. HENRY W. CAVE said that there were many points worthy of discussion in this paper. In the first place he wished to emphasize Doctor Graham's statement that most of the deaths following operation on the gall-bladder ducts are due to failure of the heart or pulmonary complications. To diminish complications he had used at the Roosevelt Hospital for the last year and a half in a majority of the gall-bladder operations avertin, nitrous oxide and oxygen with ether for closure; in a few instances he had used block anæsthesia with novocaine. He had not used spinal anæsthesia except in two instances. For some years past they have used at the Roosevelt Hospital the method of blowing out the lungs with carbon dioxide at the end of the operation; they are not doing it at the present time, having

## NEW YORK SURGICAL SOCIETY

been influenced by the work of Dr. Donald S. King of Boston. Doctor King had gotten together a series of cases with controls where he had used carbon dioxide at the close of the operation and found there was no difference in the results. He also used the method of moving patients from side to side for some time after the close of the operation. He found many of the patients contracted pneumonia, nevertheless, so he discarded the use of carbon dioxide on the basis that if there is a little mucus in the large bronchial tree this might be forced down in the smaller bronchials of the lung. Doctor Graham had mentioned the use of calcium chloride or lactate in cases where post-operative hæmorrhage was feared, but Doctor Cave said he preferred to use transfusions of white blood, as he felt it was a more efficient preventive against hæmorrhage than calcium. As to the closure of the wound the speaker agreed with Doctor Heyd that it was safer to drain. He had on rare occasions closed gall-bladder cases without drainage, but he remembered a case Doctor Whipple had reported of bile peritonitis due to this. It did not take much longer to put in the drain at the upper angle of the wound or stab wound in the flank as it acts as a safety valve in cases where there was a leak in the cystic duct. Doctor Cave then showed slides illustrating the closure of an abdominal wound which he believed would diminish the incidence of incisional hernia.

DR. CHAS. GORDON HEYD stated that Doctor Graham had introduced once again the somewhat controversial question as to whether surgery should be undertaken in the acute phase of cholecystitis. It seemed to Doctor Heyd that this question had been adequately settled in that sepsis was sepsis whether it was in the gall-bladder or the appendix: that one of the most certain roads to death was uncontrolled sepsis. While an acute gangrenous appendicitis should require immediate operation, there was a certain latitude of delay in operating on acute cholecystitis but the emergency indication was one of degree and not of principle. Doctor Heyd was of the opinion that mortality and morbidity were lessened by surgical intervention in acute cholecystitis. He urged the technic of what could be termed intra-vesical enucleation of the gall-bladder. This consisted in bisection of the gall-bladder from the fundus to the cystic duct and removing the mucous membrane en masse. It was somewhat bloody but could be accomplished readily owing to the line of demarcation between the serosa and the subjacent tissues. After the removal of the case, so to speak, of the gall-bladder, the incision in the gall-bladder was sutured and a tube placed in the gall-bladder much after the fashion of a cholecystotomy. Upon removal of the drainage tube fibrosis took place and an intraperitoneal cholecystectomy was practically accomplished.

Doctor Heyd stated that he had never removed a gall-bladder without placing a strip of rubber tissue in Morrison's space. He recalled four cases of other services at the hospital that had to be re-operated on for bile leakage. He did not believe that convalescence was delayed or was more pain-

## IMPORTANT FACTORS OF CHOLECYSTITIS

ful by the introduction of a rubber tissue drain. In regard to mortality statistics Doctor Heyd was inclined to believe that mortalities among competent operators were largely the luck of the "run of the cases." For example, in 433 personally operated cholecystectomies there were twenty deaths, or approximately 4.7 per cent. mortality. There were eight additional mortalities where, in addition to the cholecystectomy, some type of gastric operation was performed, which brought the mortality to 6.7 per cent., yet in 1924 Doctor Heyd had fifty-one cholecystectomies without a death, in 1930 forty cases with four deaths and in 1933 forty-four cases with one death. It was obvious that depending upon what years were taken there was a wide variation in the mortality statistics without any comparable change in operative technic. The speaker was inclined to disagree with Doctor Graham in that he thought mortality statistics by and large were improving, that while there might be the same relative mortality rate; the absolute mortality rate was less. More people were being operated upon earlier for their gall-bladder disease and this certainly must have a beneficial effect upon the death rate. In addition, he thought the last few years have shown a marked improvement in the ability of the surgeon to protect more adequately his patient before operation. A patient with an exacerbation of chronic gall-bladder disease is more apt to have two major complicating features; one was dehydration, and the other loss of blood chlorides by vomiting. It was of the utmost importance to maintain adequate water balance. This meant that there should be taken by the patient at least 3,000 cubic centimetres of fluid a day. The addition of dextrose or glucose, aside from being valuable as an easily assimilable food and heat substance, had the unusual property of holding fluids in the tissue and hence was a valuable synergistic agent for overcoming dehydration. Any liver or gall-bladder condition that is characterized by persistent vomiting brings about a marked hypochloræmia and the important indication when vomiting is present is to provide a proper amount of chlorides by the introduction of 500 cubic centimetres of 2 per cent. solution of sodium chloride intravenously or if a more rapidly acting salt therapy seems necessary 20 cubic centimetres of 10 per cent. solution of sodium chloride intravenously. Furthermore, it seems unwise to give glucose solution subcutaneously as there is a tendency for the formation of sloughs and foreign-body tumors. It seemed wiser to reserve the administration of glucose solution either by mouth, rectum or intravenously. In conclusion, Doctor Heyd thought that with the standardized procedures the general mortality rate must of necessity show improvement.

DR. CONDUCT W. CUTLER, JR., said that some reference had been made in this paper to the mortality statistics. He had gone over the statistics at Roosevelt Hospital and found that from 1921 to 1931 there was a mortality of 9.3 per cent. for cholecystectomy. From then to the present time the figure was 3.3 per cent. This would indicate that patients are being chosen more carefully as to ability to withstand operative procedure. As to the functional liver test of Evarts Graham, during the last two years in gall-

## NEW YORK SURGICAL SOCIETY

bladder cases the speaker had made a study of this test as it compared with and related to post-operative morbidity and mortality; and in a series of seventy-five cases there was found no definite constant relation. The test confirms, but does not supersede other clinical and laboratory data as to the patient's ability to withstand operation successfully. The third point of interest was that of drainage. As to this, Doctor Cutler agreed with Doctor Heyd and Doctor Cave. He has seen no instance in which the patient's recovery was impaired or delayed by its use. There is a growing tendency toward early operation in cholecystitis, within the first forty-eight hours, and there is a great weight of authority for it. On Doctor Cutler's service they have not kept up with this procession and still prefer, where the patient is ill, to delay operation until acute symptoms have subsided. Where there is acute sepsis which does not show evidence of subsiding within forty-eight hours, operation should be performed, but in that situation the simplest and shortest procedure is the one most appropriate, such as cholecystostomy, rather than cholecystectomy. The patient is almost invariably, in the acute stage, suffering from dehydration and possibly from jaundice and cholangitis and to subject him to cholecystectomy is to subject him to a greater risk. The acute case is as much in need of rehabilitation as is the chronic case. He is suffering from chronic cholecystitis plus an acute exacerbation.

## BRIEF COMMUNICATION

### OSTEOCHONDROMA OF CHEST-WALL

A MAN, twenty-three years of age, first noticed a lump in the left side of his chest at the age of sixteen. It grew slowly and progressively for four years, reaching the size of a football. It caused very little trouble until four months ago when he noticed throbbing in the epigastrium. He has become fatigued easily, has spells of dyspnoea and has rather severe palpitation. Family and past history irrelevant. The tumor involved the lower part of the left lateral thoracic wall. It was hard, nodular and firmly attached to the ribs, but not to the overlying skin. Running vertically over this tumor to the groin was a greatly dilated and tortuous vein. Lungs were clear and resonant throughout except over the tumor mass where voice and breath sounds were absent. The heart was displaced to the right, the apex pushed downward, causing marked epigastric pulsation. The area of cardiac dullness was centred over the lower part of the sternum. There is a marked systolic retraction just below and inside the left nipple. The rhythm is regular, the rate slow, the sounds vigorous. There is a to-and-fro murmur of the entire precordium. There are systolic and diastolic murmurs which persist in expiration and inspiration. On admission, temperature, 99; pulse, 84; respiration, 20; blood-pressure, 110/80.

*X-ray of Chest.*—A circumscribed area showed in the left lower posterior lateral wall about the size of a football that encroached on the contents of the thorax equally as much as it extended into the soft tissues externally. It obscured the left diaphragm, and was so large the patient could not be manipulated so that the diaphragm could be seen fluoroscopically. The tumor mass encroached upon the left lung and heart, displacing the heart somewhat to the right. It apparently arose from the eighth and ninth ribs, the shafts of which could not be seen posterolaterally. Apparently, they had been destroyed with the growth of the tumor. The circumscribed character and the history of slow growth suggested its being benign. Films taken for bone detail, using very high penetration, demonstrated what appeared to be islands of cartilage within the bony tumor, giving the impression that it was a large osteochondroma. Lung fields show no evidence of other pathology except some increase in the hilar shadows. Heart shadow appears to be enlarged and what can be seen of its contour suggests a mitral lesion. December 6, 1932, the seventh, eighth, ninth and tenth ribs were resected from the tumor to just behind their angles. The mass was dissected off the diaphragm up to the pleural cavity. The posterior portion of the upper part of the tumor, its posterior aspect, and about one-half of its lower aspect were practically completely freed. All that remained to remove was the common costal cartilage and a portion of the sixth interspace anteriorly in front of heart.

Following operation he ran a temperature of about 101° and 102°. Respiration, 20-40, at times to 50; pulse, 120-140. Occasional pain in left chest and dyspnoea. Sedatives have given relief. On the sixth day post-operative, he was put in the oxygen tent and his temperature came down to 99°. Now quite comfortable. White blood count, 23,880 one day post-operative and has now fallen to 17,850. Polymorphonuclears varied from 90 per cent. to 83 per cent. X-ray two days post-operative showed resection of ribs with localized pneumothorax in right lower lobe. No fluid nor pneumonia. Friction rub was discovered sixth day post-operative, along the right border of sternum and in right axilla.

December 14, 1932, the second-stage operation for the removal of the tumor was done. Since the previous operation, the iodoform packing, that had been inserted to



## BRIEF COMMUNICATION

preserve a plane of cleavage and to aid in the promotion of lung adhesions so that further collapse might not take place, was removed from the posterior portion of the incision. The common costal cartilage on the left side was carefully dissected out and divided close to the sternum. The internal mammary vessels were ligated and the remaining adhesions of the tumor to the diaphragm and sternum divided and the whole immense mass removed. The wound was sutured with interrupted silk sutures and the patient placed in an oxygen tent at once. His condition was precarious, but with a transfusion, it improved. A continuous infusion was maintained through one of his arm veins, using saline and 5 per cent. glucose solution.

During the afternoon his condition gradually improved, and though his pulse remained rapid, he was apparently no worse and began to take fluids to drink. His bowels moved that evening. The following morning he seemed to improve. His temperature was 99°; his pulse ranged between 100 and 110. He was able to talk, smiled and talked to visitors, and it looked as though he might get well. The same night, however, his pulse became quicker; his blood-pressure began to drop; his respirations, which had been between 20 and 30 the previous day, went up to 36 and then to 50. The following morning his condition was considerably worse. His temperature was beginning to mount; his pulse was more rapid and his respirations became moist and shallow. Two days after the operation, in the afternoon, he died. The altered pressure relations and the presence of active rheumatic valvular disease had proved too great a handicap. The tumor presents a typical trabecular structure and the stroma is rather fibrous and poor in cells. A small bony nodule having the precisely similar composition is found in the left lower lobe and one is tempted to regard it as a metastatic process. Histologically, however, the main tumor conveys no suggestion of malignancy.

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## EDITORIAL ADDRESS

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